2014 Biennial Report to the Congress

as required by

The Coin Modernization, Oversight, and Continuity Act of 2010 (Public Law 111-302)

United States Mint

Department of the Treasury

December 2014

BACKGROUND

The Coin Modernization, Oversight, and Continuity Act of 2010, Public Law 111-302 (Act) (Appendix 1) authorizes the Secretary of the Treasury (Secretary) to conduct research and development (R&D) on alternative metallic materials for all circulating coins with the goal of reducing production costs. The Act also requires the Secretary to provide a biennial report to Congress on the status of coin production costs and analysis of alternative content.

As required by section 3 of the Act, each biennial R&D report must address the following three areas:

I. Production Cost Analysis: The Act requires the Secretary to analyze "production costs for each circulating coin, cost trends for such production, and possible new metallic materials or technologies for the production of circulating coins."

II. Recommendations for Changes to Coin Composition: The Act requires the Secretary to provide "detailed recommendations for any appropriate changes to the metallic content of circulating coins in such form that the recommendations could be enacted into law as appropriate."

III. Recommendations for Changes to Coin Production: The Act requires the Secretary to provide "recommendations for changes in the methods of producing coins that would further reduce the costs to produce circulating coins, and include notes on the legislative changes that are necessary to achieve such goals."

The United States Mint (Mint), a bureau of the Department of the Treasury, submitted its first biennial report in December 2012 and since then has continued its R&D on potential change to coin compositions as well as alternative manufacturing methods that would further reduce the costs to produce circulating coins. This report is the second biennial report as required by the Act.

SUMMARY

The Mint delivered 10.7 billion new coins to the Federal Reserve Banks (FRBs) in Fiscal Year (FY) 2013 – a 17.6 percent increase from FY 2012. In FY 2014, the Mint delivered 13.0 billion new coins to the FRBs – a 21.9% increase over FY 2013. Concurrently, the Mint reduced manufacturing costs. Overall, as a result of increased production volumes, Mint production cost reductions, Mint overhead cost reductions, and lower metals prices, from FY 2011 (when the Act became law) through FY 2014, the production cost of the one-cent coin (penny) has decreased 31.1 percent to $0.0166 from $0.0241; the production cost of the five-cent coin (nickel) has decreased 27.6 percent to $0.0809 from $0.1118; the production cost of the dime coin (dime) has decreased 30.8 percent to $0.0391 from $0.0565; and the production cost of the quarter-dollar coin (quarter) has decreased 19.7 percent to $0.0895 from $0.1114 (Appendix 2).

Since submitting its first biennial report, the Mint has significantly increased its outreach to those stakeholders potentially affected by changes to the metallic composition of the nation's coinage. Through its outreach, the Mint learned that coin stakeholders have concerns that new coins with alternative metal compositions may have properties that are different from our current circulating coins. The circulation of same denomination coins with different metal compositions creates unique challenges for the various coin

stakeholders. Specifically, any change to the weight, shape, and most importantly the electro-magnetic signature (EMS) used to validate current circulating coins in coin acceptors would require equipment changes, potentially costing stakeholders between $2.5 billion and $6 billion. In addition, many industry stakeholders implored that no changes be made to the quarter because of its extensive use in many coin-accepting industries (e.g., vending, laundry, amusement, and parking). Many stakeholders asked that we consider the significant cost to the industry ($2.5 billion - $6 billion) compared with the projected government savings achieved by manufacturing circulating coins with an alternative metal composition ($5 million - $57 million annually). An analysis of comments from the coin industry stakeholders is included in Appendix 3.

Since passage of the Act, the Mint conducted extensive R&D on potential alternative metal compositions for circulating coins. During initial R&D efforts, the Mint tested twenty-nine different metal formulations. Of these metals formulations, the Mint focused its R&D efforts on six metal compositions. Since the last biennial report in December 2012, the Mint conducted extensive testing of these six compositions, as well as initial testing of materials that show potential to duplicate the existing weights and EMS of current United States coinage. One of the six compositions, the 80 percent copper and 20 percent nickel (80/20) alloy offers nearly identical weights and EMS as the current nickel, thus eliminating the impact on coin industry stakeholders. The Mint needs to conduct further R&D testing of the 80/20 alloy before confirming the use of the material as the outside layer for the clad metal composition of our circulating dime and quarter coins. However, the 80/20 alloy results in only modest material savings of approximately three percent ($5.0 million annually using 2014 production volumes). Other compositions that may match the weight and EMS of current coinage, but provide additional savings beyond the 80/20 alloy, are currently undergoing testing that should conclude in 2015.

The other five alternative metals compositions are nickel-plated steel (NPS), multi-ply-plated steel (MPPS), stainless steel, copper-plated zinc (CPZ), and tin-plated copper-plated zinc (TPCPZ). Of these, only the steel-based coins demonstrated acceptable wear characteristics. These steel-based alternatives offer savings of 15-20 percent (approximately $57 million annually) compared to 2014 costs. However, these steel-based alternatives require the coin stakeholder industry to make changes to recognize both new and existing coin characteristics because the two types of coins would co-circulate. Significantly, the EMS range for these steel-based compositions introduces the potential use of low-value steel coins from other countries in coin acceptance machines in lieu of higher value United States denominations, particularly the quarter.

At this juncture, there are several possible options to alter the metallic compositions that would lower the costs of United States coins, but the Mint does not recommend adopting any of these options until ongoing research is completed on a promising alternative that has the potential to duplicate the weight and EMS of existing coinage. The Mint plans to continue this research in 2015. Appendix 4 is the comprehensive technical report of the Mint's R&D efforts since the submission of the 2012 biennial report.

Regarding potential changes to coin production, the Mint, as demonstrated through its reduction in manufacturing costs, seeks continuous improvement in its production of circulating coins. In addition, the Mint investigated two alternative methodologies to produce blanks for coinage operations. The first alternative methodology involved the use of a laser to produce coin blanks. Although lasers potentially

could create coin blanks, none of the analyses showed a strongly favorable economic outcome for laser blanking. A second initiative identified a die-blanking with a push-back system, which could eliminate the expense of on-site annealing. The push-back system is very similar mechanically to the Mint's current die-blanking system and would is expected to have a low capital investment. The Mint plans to conduct additional study of the push-back die blanking system and to evaluate this equipment change in conjunction with its annual capital budget process.

Production Cost Analysis

In both FY 2013 and FY 2014, orders for new coins by the FRBs increased for the penny, nickel, dime, and quarter. In FY 2009, the Mint experienced a significant decline in FRBs coin orders and accordingly reduced its manufacturing operations at Philadelphia and Denver from three eight-hour shifts to two ten-hour shifts per day. Without increasing staff, the Mint is now producing circulating coins at the pre-FY 2009 levels with two shifts instead of three.

Since the last biennial report, circulating cost of goods sold increased 17.8 percent in FY 2013 over FY 2012 with another increase of 13.5 percent in FY 2014, mainly due to increased volumes. A decrease in the base metal spot prices for copper, nickel, and zinc on the metals market saved the Mint about $1.9 million in FY 2013 compared with FY 2012. In FY 2014, base metal spot prices declined over FY 2013 for copper (6.9 percent) while the price of zinc and nickel increased (8.4 percent and 3.9 percent, respectively). As a result, the Mint saved $28.8 million in FY 2014 compared with FY 2013. In addition, the Mint reduced overhead costs 3 percent at the Denver and Philadelphia Mints in FY 2013 compared with FY 2012. The Mint also controlled indirect costs in FY 2014, allowing the increased shipments to generate more seigniorage. Plant costs at the production facilities at Denver and Philadelphia increased only 1.7 percent (excluding a one-time establishment of an allowance last year for supplies of $6.7 million), despite the 21.9 percent increase in coin production. General and administrative costs increased slightly with increased research and development expenses.

With production of the circulating dollar coin suspended early in FY 2012, the Mint anticipated seigniorage to be lower in FY 2013; however, due to increased demand for the quarter by the FRBs seigniorage exceeded the FY 2012 amount. As a result, the seigniorage per dollar issued performance increased to $0.24 in FY 2013 from $0.21 in FY 2012. Again, due to an increased demand for the quarter and the decrease in metal costs in FY 2014, the seigniorage per dollar issued performance increased to $0.37 in FY 2014.

Coin Industry Stakeholder Outreach

In July 2013, through the Department of the Treasury, the Mint established the Office of Coin Studies to develop a more in-depth outreach to coin industry stakeholders in an effort to understand how circulating coins produced with alternative metal compositions might affect commerce. The process included conference calls, webinars, conference presentations, and electronic outreach utilizing e-newsletters and e-magazines. The Office of Coin Studies created, and continues to maintain and expand, a database on industry stakeholders, developed and implemented an industrywide stakeholder outreach meeting, fostered communication between industry groups, and created and sustained a continuous feedback loop between industry stakeholders and the Mint. In addition, Mint staff encouraged and participated in a

number of meetings with associations that represent industries dependent on circulating coins for their business operations. The Mint published a *Federal Register notice* (FRN), soliciting coin industry comment, in April 2014.

Following the heightened outreach program, the April 2014 FRN generated 962 comments, of which 99 percent received were directly responsive to the request for commentAmong the 962 contributors are the American Bankers Association (ABA), National Armored Carrier Association (NACA), National Bulk Vending Association (NBVA), Coin Laundry Association (CLA), Multi-Housing Laundry Association (MHLA), American Amusement Machine Association (AAMA), Amusement & Music Operators Association (AMOA), National Parking Association (NPA), International Parking Institute (IPI), a newly formed coalition called "Don't Change Our Change" (DCOC) representing 226 small businesses, and over 700 additional medium and small businesses. Based on comments from the coin industry stakeholders, a transition to an alternative metal with co-circulate characteristics would cost between $2.4 billion and $6 billion to accommodate new coins.

The Act specifically requires that the Secretary shall consider factors relevant to the ease of use of and ability to co-circulate new coinage materials, including the effect on vending machine and commercial coin processing equipment and making certain, to the greatest extent practicable, that any new coins work without interruption in existing coin acceptance equipment without modification. From responses received and initial analysis, the Mint segmented feedback by the role each contributor plays within the industry. The three primary roles are: (1) *equipment manufacturers*, companies involved in the manufacture of coin processing and acceptance equipment; (2) *logistics*, those whose primary role involves the distribution, packaging and storage of coin; and (3) *commerce*, any business that is dependent on coin in the conduct of business to include retailers, vending machine operators, transit operators, and municipalities managing parking garages and/or meters.

Equipment manufacturers emphasized that any change that alters size, design, or content of a coin without comprehensive consultation and coordination with the industry could harm the economy. Specifically, if coin design or material content changes are orchestrated hurriedly without regard to the equipment and other stakeholders, the currently reliable United States coin circulation infrastructure could be adversely affected or fail altogether. In addition, co-circulating same denomination coins with different weights would be ruinous for coin weighing technology, as co-circulating coins would have to be separated for counting.

Logistics sector includes depository institutions (banks) and the armored carrier industry. The ABA recommended no changes be made to the metallic composition of U.S. coinage in circulation at this time. The ABA cited changing the weight or dimensions of a coin would present serious challenges to banks because bulk coinage is counted by weighing bags of coins. If the weight changes in new coins, then banks and armored carriers would need to keep new and old coins separate. This would slow the counting process and would increase personnel costs. The ABA went on to note changes to circulating coins would result in the additional cost for new equipment and higher charges for services provided to businesses and consumers. In addition, the ABA raised concerns about changing the EMS of coins, as this would result in a similar outcome. The NACA recommended no changes be made at this time to the sizes or metallic composition of currently circulating U. S. coins. The NACA also expressed concern that an alteration of coins' weights could eliminate weighing as an option for bulk verification and

significantly and negatively influence productivity. Alternatives metals resulting in heavier coins would affect transportation costs through higher fuel costs due to the increased weight and the potential of multiple trips to service customers due to weight limits as well as wear and tear on coin handling equipment and armored vehicles.

Commerce sector comments received by the Mint included NAMA, NBVA, CLA, MHLA, AAMA, AMOA, NPA, IPI, DCOC, and over 700 additional medium and small businesses. NAMA stated that the Act requires consideration be given to the impact on vending. The NAMA feedback indicated the most significant potential impact of a change to circulating coin composition would be to those industries that use machines that accept coins for automated payments. These machines rely on acceptors that discern the EMS, weight, and shape of each coin to identify its value. NAMA estimates there are seven million vending machines across the country and the cost of these changes could amount to $3.5 billion for the vending industry, negatively affecting the entire vending and food service channel and its consumers.

NBVA, CLA, MHLA, AAMA, and the AMOA opposed changing the composition of the quarter. Specifically, changing this coin's weight, EMS, or size would have immediate and significant impacts on these industries. NPA provided feedback relating to small business owners, as well as public entities. NPA noted the parking industry would be particularly disadvantaged by changes because the majority of commercial operators are small to medium sized, privately held firms. These companies would be faced with costly decisions to automate operations, or even close their doors. For larger operations, both public and private, the cost of new equipment, training, software, and changes to business systems across their operations would be a financial and operational burden. IPI noted concern regarding the composition of new coins relating to content, weight, dimension, and EMS. Regarding conversion costs, without the benefit of knowing the actual changes being considered to circulating U.S. coins, IPI estimated that retrofitting parking meters could cost $200 - $300 per machine, excluding labor. The burden for the owners, both private and municipalities, could exceed $400 million.

DCOC is a coalition of associations and organizations that primarily represent small business owners, their suppliers, distributors, employees, and customers, all of whom would be affected by a change in coin composition. There were 226 letters received from this group. The DCOC letter specifically noted, "changes to coinage will create an added expense, at best, and could mean the difference between a thriving or failing business for many coalition members." The letter further noted there are approximately 10 million coin-operated machines with cost estimates of $100 to $500 per machine to retrofit depending on the requirements. Further impact could include: (1) co-circulation resulting in unknown consequences; (2) uncertainty associated with the length of a transition period; (3) increased service of equipment; and 4) the savings recognized from the composition change would be offset by a reduction in tax revenue.

R&D Alternative Metals

After Phase I concluded in December 2012 with the issuance of the biennial report, the Mint continued its research into alternative metals, rejecting some of the materials recommended in that report, and identifying six materials that would form the major effort for continued testing in Phase II. Beyond those six compositions, however, the Mint continued to consider and evaluate other, potential, alternative materials.

For Phase II testing, the following materials were evaluated on the coins indicated:

	Material	Composition	Tested On
1	Copper-plated zinc (CPZ)	Copper plated on zinc (identical to current one cent)	Nickel
2	Tin-plated CPZ (TPCPZ)	Tin plated on copper plated on zinc	Nickel
3	Nickel-plated steel (NPS)	Nickel plated on low-carbon steel	Nickel Quarter
4	Multi-ply-plated steel (MPPS)	Nickel plated on copper plated on nickel plated on low-carbon steel	Nickel Quarter
5	Stainless steel	Austenitic (non-ferromagnetic) stainless steel, monolithic	Nickel
6	80/20 cupronickel (80/20)	80 percent copper, 20 percent nickel, monolithic	Nickel*

* 80/20 alloy was only tested on the nickel, but was expected to be clad to copper for higher denominations if it passed.

The Mint chose the top five listed as "co-circulate" materials, which would not have the same EMS or piece weight as the material of same-denomination coins that are currently in circulation (current material). The Mint chose the 80/20 alloy as a "seamless" material, which matches the current material's EMS and weight, and has no appreciable impact on the coin-accepting industry.

The Mint purchased all materials except stainless steel in variability lots, which were laboratory-produced and contained 500–2,000 pieces made to specifications to provide the expected range of material in production. Those materials that passed the variability lot testing were then purchased in pre-production lots, which were much larger, typically about two million pieces. Pre-production lots were produced on the supplier's normal manufacturing lines over separate production runs to evaluate material that would be representative of actual production.

During variability testing, materials were processed through progression strikes to show how varying strike force (in metric tons, or tonnes) would affect the material's detail ("fill") as compared with the current coins. The Mint also put test pieces through a two-week wear test, a steam test designed to test the material's resistance to color change, and various other tests such as conductivity, hardness, and EMS. Then, the materials had to pass a Go/No-Go determination based on seven criteria.

TPCPZ and CPZ both failed their Go/No-Go determinations because of poor results on the wear test. NPS and MPPS passed their Go/No-Go determination (although the security requirements of the quarter had not been finalized at that time), and the Mint purchased those materials for pre-production testing.

The original 80/20 alloy's EMS did not match that of the current material. However, a slightly modified version of the 80/20 alloy, which substituted manganese for some of the nickel to achieve the conductivity and EMS of the current material, showed promise. Accordingly, the Mint procured 500 pieces of this modified 80/20 alloy for evaluation through progression strikes and for wear and discoloration tests. The Mint also tested the modified 80/20 alloy's EMS at three different external coin

acceptor manufacturers that all confirmed an EMS match with the current material. The Mint determined that modified 80/20 alloy passed its Go/No-Go determination and, accordingly, it purchased additional quantities for pre-production testing.

The Mint purchased NPS and MPPS in nickel and quarter coin configurations and the modified 80/20 alloy in a nickel coin configuration for the pre-production testing. Initially, NPS and MPPS proved to have poor striking qualities in the variability testing. However, the Mint consulted with The Royal Mint (RM) and the Royal Canadian Mint (RCM), both of which have experience with these cold-rolled, low-carbon, plated-steel materials, and identified various changes to resolve these issues. After the consultations, the Mint sent nonsense dies (dies that are comparable to those used for regular coin, but contain different devices and nonsensical inscriptions to clearly distinguish their resulting products from genuine coins) to RM and RCM to benefit from their expertise with physical vapor deposition (PVD) coatings for dies used on their products that must withstand the severe abrasion associated with nickel plating on both of the plated-steel materials.

The RM and RCM sent to the Mint quantities of both materials, which showed improvement, but there were problems with die life and fill. After more interaction with the RM and RCM, the Mint received pre-production lots and conducted full tests on both plated-steel materials. The die life still proved significantly less than with the current material. The Mint determined that noticeable changes to the coin aspects (including adjustment to the height of relief/crown, smoothing design features, softening letters, and less-detailed images in general) would be needed to improve coinability. In addition, planchet profiles and blank lubrication would need optimization. The tests suggested that the plated-steel materials will not surpass or even match the current material in coinability.

The Mint also investigated stainless steel as a co-circulate option, either as a monolithic material for the nickel, or as a clad material for the dime, quarter, and half-dollar. The security requirements of the quarter and higher denominations make this easily counterfeited material unsuitable for those denominations, though it would be feasible for the nickel. Further testing would be required to determine its feasibility for the dime.

Currently, ninety-two countries use bi-metallic materials for circulating coins. The Mint researched the potential of using bi-metallic materials for the nickel coin configuration including potentially using the current penny as the center with an outer ring made from the current nickel coin composition. The bi-metallic study recommended not using circulated or unstruck planchets of the current penny for a bi-metallic nickel coin composition. The study concluded the capital cost required for the Mint to produce bi-metallic coins would increase the unit cost of coins by approximately 0.0066 $/coin. Consistent with observations of other countries using bi-metallic coins the study recommended the use of bi-metallic coins with a face value greater than or equal to one dollar.

The Mint is still researching other alternatives to the materials already tested in this report. Of note are coins made of a variation on “nickel silver,” a material composed of copper, nickel, and zinc that has a silver appearance. The variation, alloy C77000, is expected to yield a coin that not only has the same EMS as current coins, but like the 80/20 alloy also has a weight that falls into the acceptable variation on current coins. The Mint is partnering with the National Institute of Standards and Technology, a bureau of the Department of Commerce, to pursue an alloy development project.

The Mint is also investigating plated coins that use a silicon-steel core, not used elsewhere in the world that could have a unique EMS. Silicon steel is commonly referred to as "electrical steel" and has a similar price to low-carbon steel.

Findings and Conclusions

Two separate types of alternatives were considered during Phase II testing and evaluation. The first was a material with an EMS and piece weight that was potentially seamless with the current circulating coinage compositions (80/20 alloy). The second was co-circulate alternatives in which the EMS differed from the current material and the piece weight would vary from the current material by 4 percent or more (NPS, MPPS, Stainless steel, CPZ, TPCPZ). Potentially seamless alternatives would not require changes to the coin acceptors, but would offer only modest material savings (approximately 3 percent). Co-circulate alternatives provide much greater materials savings (approximately 20 percent), but would require significant stakeholder conversion costs to accommodate the different EMS and piece weight. Table 2-12 (Appendix 5), which is an excerpt from the Technical Report (Appendix 4) shows the estimated cost breakdown of current and alternative metals.

Seamless Material

1. A variant of today's current cupronickel composition, termed the 80/20 alloy, which has a lower nickel content with higher manganese content, was found to be seamless when tested by three separate coin-acceptor manufacturers.[1] The Mint estimated this material would provide approximately $5.25 million annual savings ($3.2 million for the nickel, $0.8 million for the dime, and $1.25 million for the quarter) with no impact on the public or on stakeholders.

2. The 80/20 alloy matches the current material in both EMS and in piece weight, having a weight that falls within legally accepted variances for the current material.

3. Initial testing of other, potentially seamless, leaner-copper alternatives shows potential for further incremental material savings without presenting any color changes or corrosion-resistance changes.

Co-Circulate Materials

4. Plated-steel materials are a viable option for the nickel and potentially the dime, and offer approximately $22 million to $29 million in savings annually over current materials. Plated-steel materials for the quarter offer an additional $25 million to $27 million in annual savings; however, plated-steel materials have increased risks of fraud and counterfeiting, and are used in low-value foreign coins, all of which make the materials not feasible for use in the quarter. Plated-steel materials also cause a significantly lower die life, which, if not mitigated (see #6, below), could increase production and labor costs, and reduce the savings the materials might offer.

5. Stainless steel, while resistant to corrosion, has a hardness that can negatively affect its coinability. Control of cold-rolling reduction and proper annealing of the right grades demonstrated the ability to mitigate this factor, and improves the coinability of stainless steel.

[1] In testing, 80/20 alloy nickel pieces were 100 percent accepted by all three coin-acceptor manufacturers.

Production Improvement

6. The Mint explored options of adjusting the height of the relief and crown on the current coin to address unacceptable fill on some materials. However, this change introduced other issues, such as outer elements (e.g., the border) filling before inner element, or the flow of the material changing. It became clear that changes to the coin features—including adjustments to the height of relief or crown, planchet profile, smoothing of design, softening of the letters, and less-detailed images in general—must be treated as a collective system. This system involves not only the items mentioned here, but also matching planchet-die geometry; strike force; die lubrication, coating, and polishing; and other variables.

Terminated Materials

7. Testing of plated zinc alternatives CPZ and TPCPZ showed insufficient wear and durability properties for consideration on denominations other than the current penny coin's CPZ application. Additionally, TPCPZ exhibited galvanic corrosion when copper and tin, two dissimilar metals, were exposed to the environment during wear, rendering this construction unsuitable for U.S. coins aside from the penny.

R&D Changes to Coin Production

In accordance with the Act, the Mint is seeking ways to reduce the cost of producing circulating coins. The Mint investigated the technical and financial feasibility of using laser blanking in two ways that showed promise: (1) replace the current mechanical die blanking and on-site annealing with laser blanking and off-site bulk annealing; and (2) retain the on-site annealing and exchange die blanking with laser blanking.

A thorough review of the technical issues found no significant concerns. The review involved laser cutting nine different materials and making sample coin blanks. The sample blanks were characterized for diameter, burr, knit-line, edge condition, grain structure, and hardness in the area adjacent to the laser cutting. Laser cutting of the monolithic nickel coin material was found to be faster and at better edge quality than with any of the clad materials (dime, quarter, and dollar coins). Sample lots of 100 pieces of nickel, dime, quarter, and dollar coin blanks were sent to the Mint for evaluation.

A conceptual design was developed along with three-dimensional, computer-aided design images, showing how multiple lasers, working in parallel, could meet the production needs of the Mint. In addition, an environmental assessment was performed, which yielded no significant concerns.

The feasibility review included several economic analyses using a range of assumptions, but none of the analyses showed a strong favorable economic outcome for laser blanking. The production capacities of laser blanking machines that are equal to the current die blanking machines are economically unfavorable. Perhaps in the future, if lasers cut faster or become less expensive, that situation might change, but currently a transition to laser blanking does not appear to offer financial benefits.

In the course of this study, the Mint identified a promising alternative to laser blanking called die blanking with a push-back system, which could eliminate the expense of on-site annealing. This system is very similar mechanically to the current die blanking and the capital investment appears to be low.

Either laser blanking or push-back blanking could eliminate on-site annealing, but only push-back blankiing is likely to result in an overall cost savings.

Conclusions and Recommendations

1. There are no alternative metal compositions that reduce the manufacturing unit cost of the penny below its face value.

2. Based on the response from coin industry stakeholders, the estimated industry cost ($2.4 billion to $6 billion) to accommodate an alternative metal for circulating coins that incorporates a change to the weight or EMS characteristics far exceeds the estimated annual government savings ($46 million to $57 million) (Appendix 5).

3. The coin industry stakeholders overwhelmingly recommended no change to the quarter.

4. The Mint does not recommend the use of copper-plated zinc or tin-plated copper-plated zinc for circulating coins with a face value equal to or exceeding five-cents. In addition, the Mint does not recommend the use of multi-ply-plated-steel or nickel-plated steel for circulating coins with a face value equal to or greater than twenty-five cents.

5. Based on the coin industry response as well as the Mint's R&D results, the Mint should evaluate the potential cost savings ($5.25 million annually) of alternative metal compositions that meet the seamless criteria of no change to the weight or EMS characteristics for circulating coins and its corresponding effect on the coin stakeholders.

Next Steps: Planned Areas of Further Study

1. Continue seamless 80/20 alloy testing and evaluation
    a. Continue larger-scale testing of modified 80/20 alloy and develop a final specification that can be utilized by current and other strip suppliers.
    b. Conduct feasibility, variability, and pre-production testing on cladding modified 80/20 alloy to a copper core as an alternative for the clad denominations of dime, quarter, and half-dollar coins. The direct cost savings from this change would be limited, but continuing to clad these coins with the same alloy used for nickel would streamline material production.
    c. Report findings before the end of FY 2015.

2. Pursue seamless alloy development

    Continue alloy development of other, potentially seamless, leaner-copper alternatives to provide opportunity for additional incremental materials savings without affecting coin acceptors and coin processors. Initial testing indicates further opportunity for incremental material cost reductions with a composition evolving over several progressive steps.

3. Continue stainless steel R&D
    a. Continue larger-scale variability and pre-production testing on the two stainless steel grades that we identified in the Stainless Feasibility Study as having potential for use as circulating coinage material.
    b. Conduct testing and evaluation of monolithic stainless steel as a clad outer layer as a co-circulate material. Engineering calculations indicate this combination could exhibit a similar EMS to the current clad coins and enable the copper core thickness to be reduced, providing incremental material savings, and a reduction in the use of the more-expensive and price-volatile nickel. Its piece weight, however, would be lighter.

4. Explore production improvements

    a. Investigate push-back blanking and determine if it is a technically feasible and cost-effective production method that would enable elimination of internal annealing on strip material.
    b. Pursue more-structured test strikes on different coin materials, modified design aspects, and upset profile configurations to increase the Mint's understanding of the overall coin manufacturing system. These results can be utilized to improve production efficiencies on current coin materials and provide for quicker evaluation of future materials. Results from structured trials can be used to support predictive model development and reduce the need for time-consuming iterative test strikes.

5. Continue coin industry stakeholder outreach

    a. Continue to engage the industry stakeholders regarding the Mint's R&D efforts as well as further discussions to understand the timeframes required for the industry to accommodate alternative metal coins with seamless or co-circulate characteristics.
    b. Engage the industry stakeholders about current and future business trends affecting the use of coins.

6. Initiate studies to understand consumer behavior regarding the use of coins for commerce.
    Conduct public surveys and focus groups to understand consumer behavior better regarding the use of coins for commerce. This will improve the Government's understanding of, and planning for, the future of money.

Appendices

Appendix 1: Public Law 111-302 – Coin Modernization, Oversight, and Continuity Act of 2010
Appendix 2: Production Cost Analysis with Circulating Metal Commodity Metal Prices
Appendix 3: Coin Industry Stakeholder Feedback Report
Appendix 4: Alternative Metals Study Phase II Technical Report
Appendix 5: Table 2-12. Estimated Cost Breakdown – Current and Alternative Metal

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PUBLIC LAW 111–302—DEC. 14, 2010

COIN MODERNIZATION, OVERSIGHT, AND CONTINUITY ACT OF 2010

Public Law 111–302
111th Congress

An Act

Dec. 14, 2010
[H.R. 6162]

To provide research and development authority for alternative coinage materials to the Secretary of the Treasury, increase congressional oversight over coin production, and ensure the continuity of certain numismatic items.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

Coin Modernization, Oversight, and Continuity Act of 2010.
31 USC 5101 note.

SECTION 1. SHORT TITLE.

This Act may be cited as the "Coin Modernization, Oversight, and Continuity Act of 2010".

31 USC 5112 note.

SEC. 2. AUTHORITY TO CONDUCT RESEARCH AND DEVELOPMENT ON ALL CIRCULATING COINS.

(a) IN GENERAL.—To accomplish the goals of this Act and the requirements of subchapter II of chapter 51 of title 31, United States Code, the Secretary of the Treasury may—

(1) conduct any appropriate testing of appropriate coinage metallic materials within or outside of the Department of the Treasury; and

(2) solicit input from or otherwise work in conjunction with entities within or outside of the Federal Government including independent research facilities or current or potential suppliers of the metallic material used in volume production of circulating coins,

to complete the report referred to in this Act and to develop and evaluate the use of new metallic materials.

(b) FACTORS TO BE CONSIDERED.—In the conduct of research, development, and the solicitation of input or work in conjunction with entities within and outside the Federal Government, and in reporting to the Congress with recommendations, as required by this Act, the Secretary of the Treasury shall consider the following:

(1) Factors relevant to the potential impact of any revisions to the composition of the material used in coin production on the current coinage material suppliers.

(2) Factors relevant to the ease of use and ability to co-circulate of new coinage materials, including the effect on vending machines and commercial coin processing equipment and making certain, to the greatest extent practicable, that any new coins work without interruption in existing coin acceptance equipment without modification.

(3) Such other factors that the Secretary of the Treasury, in consultation with merchants who would be affected by any change in the composition of circulating coins, vending machine and other coin acceptor manufacturers, vending machine

owners and operators, transit officials, municipal parking officials, depository institutions, coin and currency handlers, armored-car operators, car wash operators, and American-owned manufacturers of commercial coin processing equipment, considers to be appropriate and in the public interest, after notice and opportunity for comment.

SEC. 3. BIENNIAL REPORT TO THE CONGRESS ON THE CURRENT STATUS OF COIN PRODUCTION COSTS AND ANALYSIS OF ALTERNATIVE CONTENT.

31 USC 5112 note.

(a) REPORT REQUIRED.—Before the end of the 2-year period beginning on the date of the enactment of this Act, and at 2-year intervals following the end of such period, the Secretary of the Treasury shall submit a report to the Committee on Financial Services of the House of Representatives and the Committee on Banking, Housing, and Urban Affairs of the Senate analyzing production costs for each circulating coin, cost trends for such production, and possible new metallic materials or technologies for the production of circulating coins.

(b) DETAILED RECOMMENDATIONS.—In preparing and submitting the reports required under subsection (a), the Secretary of the Treasury shall include detailed recommendations for any appropriate changes to the metallic content of circulating coins in such a form that the recommendations could be enacted into law as appropriate.

(c) IMPROVED PRODUCTION EFFICIENCY.—In preparing and submitting the reports required under subsection (a), the Secretary of the Treasury shall include recommendations for changes in the methods of producing coins that would further reduce the costs to produce circulating coins, and include notes on the legislative changes that are necessary to achieve such goals.

(d) MINIMIZING CONVERSION COSTS.—In preparing and submitting the reports required under subsection (a), the Secretary of the Treasury, to the greatest extent possible, may not include any recommendation for new specifications for producing a circulating coin that would require any significant change to coin-accepting and coin-handling equipment to accommodate changes to all circulating coins simultaneously.

(e) FRAUD PREVENTION.—The reports required under this section shall make no recommendation for a specification change that would facilitate or allow the use of a coin with a lesser value produced, minted, or issued by another country, or the use of any token or other easily or regularly produced metal device of minimal value, in the place of a circulating coin produced by the Secretary.

(f) RULE OF CONSTRUCTION.—No provision of this Act shall be construed as requiring that additional research and development be conducted for any report under this Act but any such report shall include information on any such research and development during the period covered by the report.

SEC. 4. MEETING DEMAND FOR SILVER AND GOLD NUMISMATIC ITEMS.

Subsections (e) and (i) of section 5112 of title 31, United States Code are each amended by striking "quantities" and inserting "qualities and quantities that the Secretary determines are".

SEC. 5. TECHNICAL CORRECTIONS.

Section 5112(u)(1) of title 31, United States Code is amended—

(1) by striking "exact duplicates" and inserting "likenesses";

(2) by striking subparagraph (C);

(3) by redesignating subparagraphs (D) and (E) as subparagraphs (C) and (D), respectively; and

(4) in subparagraph (A), by striking "of 3.0 inches" and inserting "determined by the Secretary that is no less than 2.5 inches and no greater than 3.0 inches".

SEC. 6. BUDGETARY EFFECT.

The budgetary effects of this Act, for the purpose of complying with the Statutory Pay-As-You-Go Act of 2010, shall be determined by reference to the latest statement titled "Budgetary Effects of PAYGO Legislation" for this Act, submitted for printing in the Congressional Record by the Chairman of the House Budget Committee, provided that such statement has been submitted prior to the vote on passage.

Approved December 14, 2010.

LEGISLATIVE HISTORY—H.R. 6162:

CONGRESSIONAL RECORD, Vol. 156 (2010):
Sept. 29, considered and passed House.
Nov. 30, considered and passed Senate.

○

Production Cost Analysis with Circulating Metal Commodity Metal Prices

United States Mint

Department of the Treasury

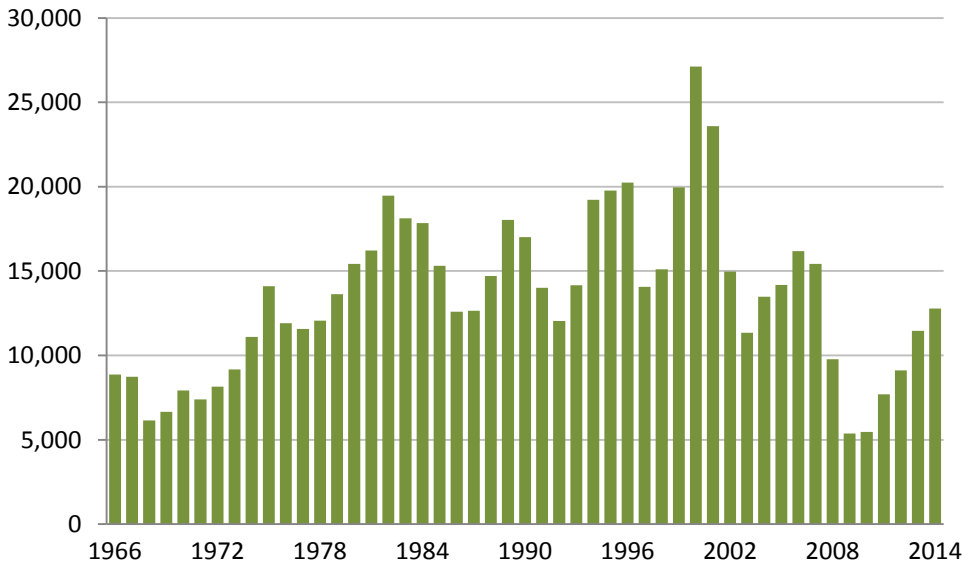
December 2014

As America's sole manufacturer of legal tender coinage, the efficient and effective production and distribution of coinage is the Mint's highest priority.

We mint and issue circulating coins to the Federal Reserve Banks (FRB) in quantities to support their service to commercial banks and other financial institutions. These financial institutions then meet the coinage needs of retailers and the public. The Mint recognizes revenue from the sale of circulating coins at face value when they are shipped to the FRB.

CIRCULATING RESULTS FY 2014 circulating coin shipments to the FRB increased by 2.3 billion units (21.9 percent) to a total 13.0 billion coins compared to last year. The year saw a marked 58.5 percent increase in quarter-dollar shipments, which drove increases in revenues and seigniorage.

Total Circulating Coin Production (coins in millions)



Shipment volumes increased for all denominations. As a percentage of total shipments, quarter-dollar shipments increased from 10 percent in FY 2013 to 13 percent in FY 2014. In contrast, the percentage of total shipments for all other denominations decreased 1 percentage point to 61 percent, 17 percent and 9 percent of total shipments for one-cent coins (pennies), dimes and five-cent coins (nickels), respectively.

FY 2014 circulating revenue was $783.0 million, 35.5 percent higher than $578.0 million last year, primarily because of a 58.5 percent increase in quarter-dollar revenues. FY 2014 seigniorage was $289.1 million, 110.4 percent higher than last year, mainly because of increased quarter-dollar shipments and lower metal costs for nickels, dimes, and quarters. Lower metal costs this year compared to last year saved us approximately $28.8 million in minting and issuing the 13.0 billion coins ordered by the FRB. The Mint also controlled indirect costs, allowing the increased shipments to generate more seigniorage. Plant costs at the production facilities at Denver and Philadelphia increased only 1.7 percent (excluding a one-time establishment of an allowance last year for supplies of $6.7 million), despite the 21.9 percent increase in coin production. General and administrative costs increased slightly with increased research and development expenses. Seigniorage per $1 issued was $0.37 in FY 2014, versus $0.24 last year.

FY 2014 unit costs decreased for all denominations compared to last year. This was because we increased production for all denominations and reduced metal costs for nickels, dimes, and quarters. By keeping indirect costs down in the face of increased demand, fixed costs were spread among more units. The unit cost for both pennies (1.7 cents) and nickels (8.1 cents) remained above face value for the ninth consecutive fiscal year. Although there was higher demand, lower unit costs generated a smaller FY 2014 loss ($90.5 million) for these two denominations compared to FY 2013 ($104.5 million).

Compared to last year, the average spot prices for zinc prices increased 8.4 percent to $2,080.92, nickel increased 3.9 percent to $16,394.01 per tonne, and average copper prices fell 6.9 percent to $6,993.38.

UNIT COST OF PRODUCING AND DISTRIBUTING COINS BY DENOMINATION

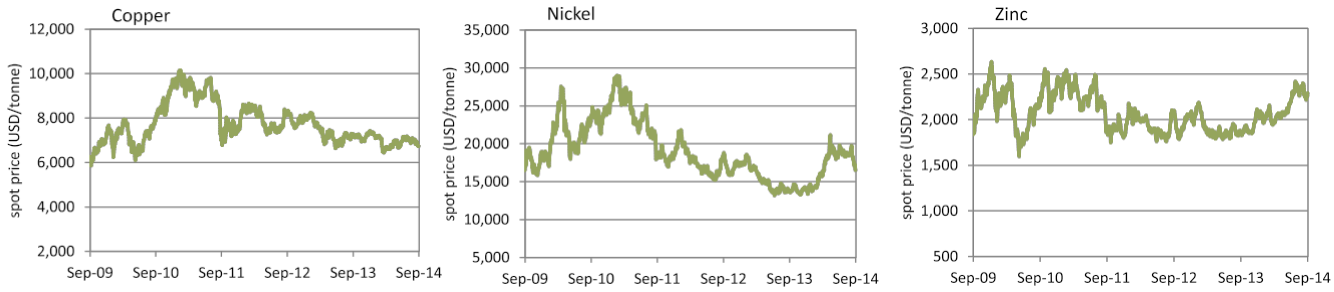
2014	One-Cent	Five Cent	Dime	Quarter-Dollar	$1 Coin
Cost of Goods Sold	$ 0.0143	$ 0.0699	$ 0.0338	$ 0.0775	$ 0.0000
Selling, General & Administrative	$ 0.0021	$ 0.0102	$ 0.0049	$ 0.0109	$ 0.0000
Distribution to FRB	$ 0.0002	$ 0.0008	$ 0.0004	$ 0.0011	$ 0.0000
Total Unit Cost	$ 0.0166	$ 0.0809	$ 0.0391	$ 0.0895	$ 0.0000

2013	One-Cent	Five Cent	Dime	Quarter-Dollar	$1 Coin
Cost of Goods Sold	$ 0.0156	$ 0.0805	$ 0.0391	$ 0.0903	$ 0.0000
Selling, General & Administrative	$ 0.0025	$ 0.0131	$ 0.0061	$ 0.0135	$ 0.0000
Distribution to FRB	$ 0.0002	$ 0.0005	$ 0.0004	$ 0.0012	$ 0.0000
Total Unit Cost	$ 0.0183	$ 0.0941	$ 0.0456	$ 0.1050	$ 0.0000

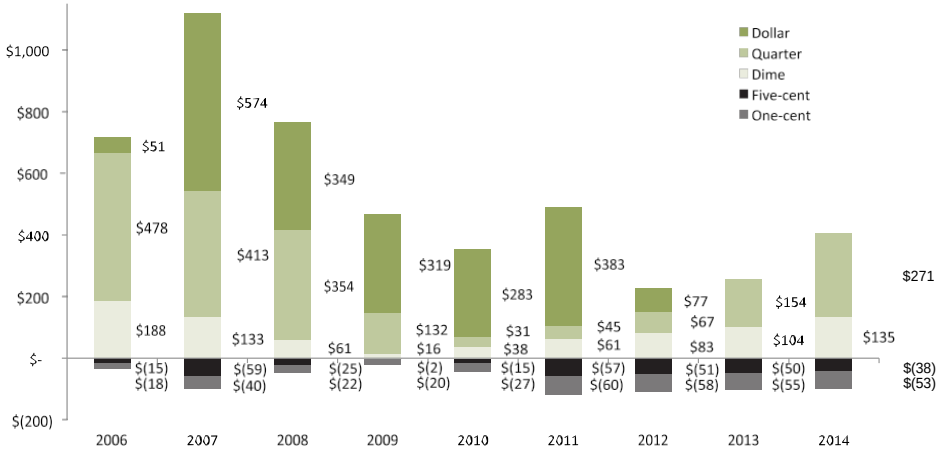
2012	One-Cent	Five Cent	Dime	Quarter-Dollar	$1 Coin
Cost of Goods Sold	$ 0.0163	$ 0.0829	$ 0.0415	$ 0.0943	$ 0.1802
Selling, General & Administrative	$ 0.0034	$ 0.0173	$ 0.0080	$ 0.0171	$ 0.0288
Distribution to FRB	$ 0.0003	$ 0.0007	$ 0.0004	$ 0.0016	$ 0.0021
Total Unit Cost	$ 0.0200	$ 0.1009	$ 0.0499	$ 0.1130	$ 0.2111

2011	One-Cent	Five-Cent	Dime	Quarter-Dollar	$1 Coin
Cost of Goods Sold	$ 0.0197	$ 0.0938	$ 0.0474	$ 0.0923	$ 0.1531
Selling, General & Administrative	$ 0.0041	$ 0.0176	$ 0.0087	$ 0.0176	$ 0.0251
Distribution to FRB	$ 0.0003	$ 0.0004	$ 0.0004	$ 0.0015	$ 0.0021
Total Unit Cost	$ 0.0241	$ 0.1118	$ 0.0565	$ 0.1114	$ 0.1803

Base Metal Daily Official Spot Price (prices per metric tonne in dollars)



Circulating Seigniorage by Year ($ Millions)



Shows seigniorage generated by denomination for the last nine years.

CIRCULATING (coins and dollars in millions except seigniorage per $1 issued)

	2014	2013	2012	2011	2010	% Change 2013 to 2014
Coin Shipments	13,037	10,696	9,082	7,396	5,399	21.9%
Value of Shipments	$ 783.0	$ 578.0	$ 493.3	$ 776.9	$ 618.2	35.5%
Gross Cost	$ 493.9	$ 440.6	$ 387.4	$ 428.1	$ 317.4	12.1%
Cost of Goods Sold	$ 435.4	$ 383.7	$ 325.8	$ 364.7	$ 239.2	13.5%
Selling, General & Administrative	$ 58.5	$ 56.9	$ 61.6	$ 63.4	$ 78.2	2.8%
Seigniorage	$ 289.1	$ 137.4	$ 105.9	$ 348.8	$ 300.8	110.4%
Seigniorage per $1 Issued	$ 0.37	$ 0.24	$ 0.21	$ 0.45	$ 0.49	54.2%

SHIPMENTS, COSTS AND SEIGNIORAGE BY DENOMINATION
(coins and dollars in millions except seigniorage per $1 issued)

2014	One-Cent	Five-Cent	Dime	Quarter-Dollar	Dollar	Mutilated & Other	Total
Coin Shipments	7,920	1,211	2,223	1,683	-	-	13,037
Value of Shipments	$ 79.2	$ 60.5	$222.3	$ 421.0	$ -	$ -	$ 783.0
Gross Cost	$ 132.1	$ 98.1	$ 87.1	$ 150.5	$ -	$ 26.1	$ 493.9
Cost of Goods Sold	$ 115.3	$ 85.7	$ 76.1	$ 132.2	$ -	$ 26.1	$ 435.4
Selling, General & Administrative	$ 16.8	$ 12.4	$ 11.0	$ 18.3	$ -	$ -	$ 58.5
Seigniorage	$ (52.9)	$ (37.6)	$135.2	$ 270.5	$ -	$ (26.1)	$ 289.1
Seigniorage per $1 Issued	$ (0.67)	$ (0.62)	$ 0.61	$ 0.64			$ 0.37

2013	One-Cent	Five-Cent	Dime	Quarter-Dollar	Dollar	Mutilated & Other	Total
Coin Shipments	6,610	1,123	1,901	1,062	-	-	10,696
Value of Shipments	$ 66.1	$ 56.2	$190.1	$ 265.6	$ -	$ -	$ 578.0
Gross Cost	$ 121.1	$ 105.7	$ 86.6	$ 111.5	$ -	$ 15.7	$ 440.6
Cost of Goods Sold	$ 104.7	$ 91.0	$ 75.1	$ 97.2	$ -	$ 15.7	$ 383.7
Selling, General & Administrative	$ 16.4	$ 14.7	$ 11.5	$ 14.3	$ -	$ -	$ 56.9
Seigniorage	$ (55.0)	$ (49.5)	$103.5	$ 154.1	$ -	$ (15.7)	$ 137.4
Seigniorage per $1 Issued	$ (0.83)	$ (0.88)	$ 0.54	$ 0.58			$ 0.24

2012	One-Cent	Five-Cent	Dime	Quarter-Dollar	Dollar	Mutilated & Other	Total
Coin Shipments	5,835	1,006	1,658	486	97		9,082
Value of Shipments	$ 58.4	$ 50.3	$165.8	$ 121.7	$ 97.1	$ -	$ 493.3
Gross Cost	$ 116.4	$ 101.5	$ 82.7	$ 54.9	$ 20.5	$ 11.4	$ 387.4
Cost of Goods Sold	$ 96.5	$ 84.1	$ 69.5	$ 46.6	$ 17.7	$ 11.4	$ 325.8
Selling, General & Administrative	$ 19.9	$ 17.4	$ 13.2	$ 8.3	$ 2.8	$ -	$ 61.6
Seigniorage	$ (58.0)	$ (51.2)	$ 83.1	$ 66.8	$ 76.6	$ (11.4)	$ 105.9
Seigniorage per $1 Issued	$ (0.99)	$ (1.02)	$ 0.50	$ 0.55	$ 0.79	$ -	$ 0.21

Alternative Metals Study
Phase II

Coin Industry Stakeholder Feedback

2014 Biennial Report to the Congress

United States Mint
Department of the Treasury

FINAL

September 1, 2014

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Table of Contents

1. Summary 1
   1.1. Introduction 1
   1.2. Stakeholder Outreach 2
2. The Manufacturing Sector 5
   2.1. Cashmaster International, Ltd. 5
   2.2. Coin Mechanisms, Inc. 6
   2.3. Cummins-Allison Corp. 7
   2.4. Jarden Zinc Products 9
3. The Logistics Sector 11
   3.1. American Bankers Association 11
      3.1.1. Impact on Banks 11
      3.1.2. CTC Alternative Metals Study 12
      3.1.3. Conclusion 13
   3.2. National Armored Car Association 13
      3.2.1. Dimensions of Circulating Coins 13
      3.2.2. Weight of Coins 14
      3.2.3. Canada's Recent Transition 15
      3.2.4. Summary 15
4. The Commerce Sector 17
   4.1. Associations 18
   4.2. Coalitions 25
   4.3. Other Small-Business Owners 26
   4.4. Other Industry Input 26
   4.5. Summary 26
5. Appendices 29
   5.1. Cashmaster, Inc. 29
   5.2. Coin Mechanisms Inc. 32
   5.3. Cummins-Allison Corp. 34

5.4. Jarden Zinc Products 38
5.5. American Bankers Association 42
5.6. National Armored Car Association 46
5.7. American Amusement Machine Association 52
5.8. Amusement & Music Operators Association 54
5.9. Coin Laundry Association 56
5.10. Canadian Automatic Merchandising Association 58
5.11. International Association of Amusement Parks and Attractions 60
5.12. International Parking Institute 62
5.13. Multi-housing Laundry Association 65
5.14. National Automatic Merchandising Association 67
5.15. National Bulk Vending Association 73
5.16. National Council of State Agencies for the Blind 74
5.17. National Parking Association 76
5.18. Additional Associations 78
5.18.1. AAMA 78
5.18.2. NAMA 80
5.18.3. AMOA 81
5.19. Don't Change Our Change 82
5.20. Small Businesses 84

1. Summary

1.1. Introduction

In July 2011, the United States Mint (the Mint) awarded Concurrent Technologies Corporation (CTC) a competitively bid contract to investigate various alternative compositions for all U.S. circulating coins. CTC's tasks included site visits, surveys, and telephone interviews with current and potential suppliers, merchants, vending machine and laundromat owners and operators, transit and parking officials, depository institutions, Federal Reserve Banks, and coin handling and acceptor manufacturers. In 2011, the Mint published a Federal Register Notice (FRN) for comment and received responses from interested parties regarding the impact of changes to the metallic composition of all circulating coins based on the factors specified in the Coin Modernization, Oversight, and Continuity Act of 2010, Public Law 111-302, section 2(b). Out of the 249 comments from this initial solicitation, only 7 percent (17 comments) were directly responsive to the request for comment.

In December 2012, the Department of the Treasury and the Mint delivered the first biennial report to Congress on the status of coin production costs and analysis of alternative content as required by the Coin Modernization, Oversight, and Continuity Act of 2010, Public Law 111-302 (Act). The Act requires that the Secretary of the Treasury shall consider:

> *Factors relevant to the ease of use and ability to co-circulate new coinage materials, including the effect on vending machines and commercial coin processing equipment and making certain, to the greatest extent practicable, that any new coins work without interruption in existing coin acceptance equipment without modification.*

The Act also makes the stipulation to minimize conversion costs, mandating:

> *…The Secretary of the Treasury, to the greatest extent possible, may not include any recommendation for new specifications for producing a circulating coin that would require any significant change to coin-accepting and coin-handling equipment to accommodate changes to all circulating coins simultaneously.*

1.2. Stakeholder Outreach

In July 2013, through the Department of the Treasury, the Mint organized the Office of Coin Studies to develop, using information collected by CTC and following further analysis, a more in-depth outreach to coin industry stakeholders in an effort to understand how circulating coins produced with alternative metal compositions may affect commerce.

The process included conference calls, webinars, conference presentations, and electronic outreach utilizing e-newsletters and e-magazines. The Office of Coin Studies (OCS) created and and continues to maintain and expand a database of industry stakeholders; developed and implemented an industrywide stakeholder outreach meeting; fostered communication between industry groups; and created and sustained a continuous feedback loop between industry stakeholders and the Mint. In addition, Mint staff encouraged and participated in a number of meetings with associations, which represented industries that are dependent on circulating coins for their business operations.

On March 13, 2014, the Mint hosted an industry stakeholder meeting at headquarters to present and discuss research and development work in alternative metals and solicit input. Thirty-eight representatives from a diverse group of industry stakeholders were in attendance. The Mint heard from the parking industry, amusement industry, armored carriers, and financial institutions as well as those who process, wrap, and recycle coins. Participants learned of the Mint's research efforts, and engaged the Mint in a dialogue about the potential impact to their industries if new metals were to be used in circulating coins. Following this meeting, the Mint published a Federal Register Notice (FRN) for coin industry comments in April 2014.

Following the heightened outreach program, the April 2014 FRN generated 966 comments, of which 99 percent received were directly responsive to the request for comment. Only two industry stakeholders, Cummins Allison and the National Automatic Merchandising Association (NAMA), contributed comments for both the 2011 FRN and the 2014 FRN request for comment. Among the 966 contributors were the American Bankers Association (ABA), National Armored Carrier Association (NACA), Canadian Automatic Merchandising Association (CAMA), National Bulk Vending Association (NBVA), Coin Laundry Association (CLA), Multi-Housing Laundry Association (MHLA), American Amusement Machine Association (AAMA), Amusement & Music Operators Association (AMOA), National Parking Association (NPA), International Parking Institute (IPI), and a newly formed coalition, "Don't Change Our Change" (DCOC), representing 227 small businesses, and over

700 additional medium and small businesses primarily affiliated with the above-noted associations.

From responses received and initial analysis, Mint staff made a determination to segment feedback by the role each contributor plays within the industry. The three primary roles are: 1) manufacturers—companies involved in the manufacturer of coin processing and acceptance equipment; 2) logistics—those whose primary role involves the distribution, packaging, and storage of coins, and 3) commerce—any business that is dependent on coins in the conduct of business, to include retailers, vending machine operators, transit operators, and municipalities managing parking garages and/or meters.

Equipment manufacturers emphasized that altering the size, design, or content of a coin without consultating and coordinating with the industry, could be disastrous for the American economy. Specifically, if coin design or material content changes are orchestrated hurriedly without regard to the equipment and other stakeholders, the currently reliable United States coin circulation infrastructure could be adversely affected or fail altogether. In addition, co-circulating same denomination coins with different weights is ruinous for coin weighing technology, as co-circulating coins would have to be separated for counting. Finally, the importance for strong communication between industry stakeholders and the Mint in preparation of the introduction of the new coins is critical and the equipment manufacturers cited the success of the Canadian $1 and $2 coin transition as an example. This segment is represented by four manufacturers and a supplier.

The Mint will use this information to make recommendations to the Department of the Treasury, which will be included in the 2014 Biennial Report to Congress, as required by the Act. In the end, only Congress has the authority to make changes to the Nation's coins.

The OCS continues an extensive stakeholder outreach program to learn what it would mean to make changes to the nations circulating coins. Through webinars, speaking engagements, Federal Register Notices, and more, the OCS is staying busy listening to the Mint's industry stakeholders and the public.

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2. The Manufacturing Sector

The Manufacturing sector includes three manufacturers and one raw material supplier. Cashmaster International; Coin Mechanisms, Inc.; and Cummins-Allison Corp. are coin-equipment manufacturers, and Jarden Zinc Products is a supplier of raw materials for use in manufacturing coins. Collectively, the three manufacturers produce equipment for authenticating, accepting, and weighing coins. They sell these machines to businesses that conduct commerce throughout the United States.

2.1. Cashmaster International, Ltd.

Cashmaster International Ltd is a global manufacturer of combined note- and coin weighing equipment. Their customers include some of America's largest retailers, restaurant chains, and other businesses which require counting cash and reconciliation in house. Cashmaster's solutions are lightweight, portable and are applicable to counting notes, coins, tokens and many other types of media.

According to Cashmaster:

> *A typical deployment of our technology is for till drawer reconciliation on a retailer's shop-floor. Cash reconciliation operations will carry one of our products from till to till, using it to count everything in the till drawer as they go. Instead of moving heavy till drawers, they can move our lightweight technology to where the cash is. This saves time and also reduces the probability of worker compensation claims for lifting injuries.*

Cashmaster asserts that "the crucial requirement for the weigh counting method is a standard coin weight. Co-circulation of coins having different weights is ruinous for coin weighing technology as co-circulating coins would have to be separated for counting." Cashmaster cites the experience of the co-circulation of the penny. "Pennies issued between 1909 and 1982 weigh 3.11g; pennies issued between 1982 and the present day weigh 2.50g each." The variation in weight contributes up to a 24 percent loss. Using a weigh counting machine, the best that can be achieved is an estimate of the number of pennies on the scale platform." While weighing the penny is still a viable option because of its low value, Cashmaster warns

that "co-circulation of higher value coins with different weights would make coin weighing technology untenable."[1]

2.2. Coin Mechanisms, Inc.

Coin Mechanisms, Inc. manufacturers both mechanical coin acceptors as well as electronic coin acceptors. Their products are used in a varied coin-op industry including Gaming, Amusement, Car Wash/Services, Vending, Transit, and other coin-op machines.

According to Coin Mechanisms Inc.:

> *The quarter coin has been the workhorse of circulating coins in the coin-op world. At the current cost of goods, the dollar coin could become the next most used coin in the coin-op industry. Eliminating the one dollar paper currency can save the Treasury millions of dollars a year and allow the Mint to leave the quarter and one dollar coin as is or as close to its current EMS[2] signature as possible. If savings in coin production are necessary, the remaining coin denominations could be more viable to significant changes that would save cost in production of those coins.*

Coin Mechanisms Inc.'s mechanical coin mechanism relies heavily on coin diameter, thickness, weight, and the alloy mix. Changing the diameter, thickness, weight, and the alloy mix would require a new and separate mechanical coin mechanism because it would be nearly impossible to accept co-existing coins in the same mechanism. In addition, any new coins would need to possess a reeded edge as some mechanical mechanisms differentiate coins based on the reeded edge and the smooth edge of the same size coins. Adding a ferromagnetic[3] coin would also sacrifice the ability of the machines to reject many types of counterfeit coins.

Coin Mechanisms Inc.'s electronic coin comparitor's series of mechanisms uses an actual physical coin or token that is placed within the device and serves as a reference to compare against coins placed in the machines. The EMS of the incoming coins must match the reference coin in order for the mechanism to validate the incoming coins. The comparing circuitry will allow the coin to be accepted if there is an EMS match or mass conductivity

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[1] Exhibit #1: Cashmaster International, US Proposed Coin Change; FRN response

[2] Electromagnetic signature

[3] Ferromagnetic means the material is attracted to a magnet

match. The comparitor cannot validate two different EMS signatures. "A redesign would be a drastic financial undertaking that is not desirable or possible at this time."

Without such a redesign, the coin acceptor mechanisms would need to have their window of acceptance opened wider to accept both the current coins and the new coins, which would mean the mechanism would accept not only those two EMS's, but all EMS's between also, rendering the machines vulnerable to fraud. If the window were not opened far enough, customers would see their old or new coins (possibly both) rejected by the machines, which would cost the machine's owners money. Finally, the process of opening the window of acceptance in every electronic coin acceptor in the Nation would be a costly undertaking.

Coin Mechanisms, Inc. says that "any change to coinage, particularly the quarter and dollar coins will result in increased costs to not only the manufacturers of the coin devices but also the makers of coin-op machines, the businesses who use these machines, and finally to the customer who buys the products from these machines. It will be very difficult for any of these groups to recoup the losses they may incur for: transition updates, difficulty in co-circulation of two different coins with the same value, fraud introduction if a more common and cheaper alloy is chosen, and vandalism from disgruntled customers who do not understand the problem using a machine in 'transition.' "

Coin Mechanisms, Inc. "…appreciates the efforts the Mint is trying to save the government money. However, it appears changing our coinage may not be worth the effort in the long run if it ultimately kills jobs, punishes small business, angers consumers, and becomes an added expense to Americans as well as the government."[4]

2.3. Cummins-Allison Corp.

Cummins-Allison Corp. is a global company that manufacturers coin counting,validating, and sorting equipment. Cummins-Allison serves the majority of retail, gaming, law enforcement, and government entities. They also have subsidiaries in Australia, Canada, France, Germany, Ireland, and the United Kingdom. Cummins Allison's coin counting, sorting, and authentication products are available in a variety of sizes and formats to meet the needs of its wide range of customers. For example, their smaller machines provide coin counting and sorting in retail operations such as McDonald's, Home Depot, and Safeway.

[4] Exhibit #2; Coin Mechanisms Inc., Coin Stakeholders Response, June 16, 2014, FRN response.

Cummins' larger, high-speed machines (which process coins at a rate of 10,000 per minute) are used in major U.S. banks, armored carriers, the gaming industry, governments, and more.

"Over a period of many years, **Cummins-Allison** has witnessed a variety of coin changes initiated by a number of countries. From our perspective, some changes have gone well and others have not." Cummins cites the changes to the Canadian $1 and $2 coins that went well.[5] "Implementation of the coin changes was not difficult for Cummins Allison, namely because the Canadian Mint routinely consulted with industry and other stakeholders to ensure their decisions were industry compatible." At the other end of the spectrum, as also noted by Cummins-Allison, "the introduction of low denomination coins in Mexico several years ago is an example of how a good intention to reduce the cost of coin manufacturing led to an undesirable result. With little-to-no industry communication and consultation, Mexico made changes to a number of their coins. In one instance they introduced a new coin that was the same size as an existing coin of a different value. Since many coin processing equipment manufacturers, including Cummins Allison, use coin dimensions to count and sort coins, the industry could not accurately process the new coin, or differentiate from an existing one."

Cummins-Allison stated that

> *…it is critical to note that any alteration to coin design, content, or size can impact the ability of our machinery to process high volumes of coins both quickly and accurately. If coin or material content changes are orchestrated hurriedly or without regard for our equipment and other stakeholder, the currently reliable US coin circulation infrastructure could be adversely impacted or fail altogether. To alter the size, design, or content of a coin without comprehensive consultation and coordination with our industry and others, could be disastrous for the American economy. In fact a poorly conceived or implemented change could impact the worldwide integrity and value of American currency, disrupt public confidence and commerce, and cost the American government many times more than what might be saved as a request of the initial cost saving alteration.*

[5] In contrast the Canadian Automatic Merchandising Association noted a number of problems refer to page 11 of 15 this report and Exhibit #11.

In summarizing their comments, Cummins-Allison said, "To achieve cost savings through new manufacturing efficiencies or coin content changes will mean nothing if the coins cannot be utilized or processed, and expensive societal cost are incurred. In addition, it is essential for new coins to contain a proper level of technology and uniqueness. U.S. coins that are susceptible to countfeiting place our economic and national security at risk."[6]

2.4. Jarden Zinc Products

Jarden Zinc Products has been the sole supplier of the U.S. Mint's penny blanks since 1998 and is also an international supplier of plated-coinage products to more than 30 other countries.

According to Jarden Zinc:

> *The Mint's stakeholder outreach and the views of industry stakeholders appear to be in conflict with the goals and purpose of the The Coin Modernization, Oversight, and Continuity Act of 2010 (Pub. L. 111-302). It is difficult to make substantial reductions in the cost of circulating coins – which by definition will include plated coins or new alloys and say there will be no effect on vending and amusement machines and commercial coin counting equipment.*

Jarden mentions "that several innovative approaches have been adopted by other countries, including plated zinc-based coinage and the Canadian multi-ply steel coin, that include significant costs savings."[7]

[6] Exhibit #3: Cummins Allison Corp., Coin Stakeholders Response, June 3, 2014, FRN response.
[7] Exhibit #4 Jarden Zinc Products, Coin Stakeholders Response, June 9, 2014, FRN response.

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3. The Logistics Sector

The Logistics sector includes depository institutions (banks) and the armored carrier industry. The functional responsibilities include transportation, distribution, storing and bulk processing to include weighing and wrapping. The American Bankers Association (ABA) and the National Armored Car Association (NACA) responded for this segment of the industry. ABA supports four recommendations from the Mint's 2012 Alternative Metals Study submitted by Concurrent Technologies Corporation (CTC):

1) Maintain existing dimensions;
2) Maintain the current composition of the penny;
3) Consider alternative, copper-based alloy changes for all other coins in search of a composition that would lower productions costs and minimize conversion costs; and,
4) Continue R&D efforts to identify metallic alloys that mimic current EMS signatures.

NACA recommends no changes be made at this time to the sizes or metallic composition of currently circulating U.S. coins. Their comments addressed concerns regarding the changing of dimensions and weight and the corresponding impact on costs, labor, transportation, and storage. NACA further noted problems which surfaced during the Canadian transition noting the importance of an extended timeframe for industry to adapt.

3.1. American Bankers Association

The American Bankers Association (ABA) is the voice of the Nation's $14 trillion banking industry, which is composed of small, regional, and large banks that together employ more than 2 million people, safeguard $11 trillion in deposits, and extend nearly $8 trillion in loans. Through a broad array of information, training, staff expertise, and resources, ABA supports banks as they perform their critical role as drivers of America's economic growth and job creation.

3.1.1. Impact on Banks

The ABA states that "Changing the weight or dimensions of a coin would present serious challenges to banks." Any changes to the weight or dimensions of coins would cause financial institutions to incur additional expenses through the upgrade of hardware and/or software. These expenses may also be passed on to the customers and or/vendors.

A change in the electromagnetic signature (EMS) of circulating coins would have a direct impact on the cost of handling coins. According to the ABA "Changing the EMS would require software programming upgrades to a very large number of devices beyond bank

oriented coin service providers and vending machines, including parking meters, car washes, toll booths, and video games."

According to the ABA:

> *Changing the color of the coins in circulations does not pose a significant challenge to the banking industry as long as the dimensions, weight, and EMS remain the same. However, color change would still require retraining employees of depository institutions to identify the coins and would require them to take more time to confirm the type of coins they are accepting for deposit or issuing in withdrawals.*

In addition, an extensive public information and education campaign would be warranted to ensure that the retail industry and consumers are aware of the new form of coins and understand that they are legal tender.

The ABA reiterates that the Act, requires the U.S. Mint to consider the potential impact of any changes to circulating coins on industry stakeholders. They define the industry stakeholder as very broad and include financial institutions, armored car services, manufacturers of coin handling equipment, municipal parking officials, toll booth operations, laundromat owners, vending machine operators, and many others. The ABA states that "Banks want to provide coins to customers that will work at all expected venues…".[8]

3.1.2.CTC Alternative Metals Study

The armored-car industry is most often a provider of coin handling services to the banking industry. These coin handling processes rely on the weight of coins. The ABA cites that the CTC study "estimated that these service providers would incur increased annual costs of $21 million annually for counting nickels, dimes, quarters, half dollars, and dollars. This is not a one-time cost for equipment upgrades but will be an ongoing expense. This expense will be passed on to these service providers' customers: banks."

Another industry that would be impacted would be the large and small vending operations. According to the CTC report, there are approximately 5.3 million vending machines in the United States. ABA agrees with the study that significant expenses would be incurred by this industry if changes were made to the dimensions of the quarter, nickel, and dime. ABA

[8] Exhibit #5 American Bankers Association, Coin Stakeholders Response, June 5, 2014, FRN response

reiterates the CTC study recommendations, based on its analysis of the cost of coin product and cost borne by the coin industry.

- Maintain existing coin dimensions for all future coins regardless of their materials for construction.
- Maintain the current composition of the one-cent and dollar coins.
- Consider alternative copper-based alloy changes for all other coins in search of a composition that would have lower production costs and that would minimize conversion costs to coin industry stakeholders with regard to changes in coin weight.
- Continue research and development efforts of metallic alloys that would mimic the current EMS signatures of the incumbent dime, quarter, and half dollar coins to avoid the need to upgrade coin processing equipment.

The ABA supports these CTC study recommendations."

3.1.3.Conclusion

The ABA states that "significant changes to the weight, dimensions, or EMS may require a similarly lengthy implementation period." "It is our view that a transition period of 24–30 months beginning when test samples are provided would be necessary, adding additional weight to the view that such changes would not be worth the costs and difficulties imposed." ABA recommends "no changes be made to the metallic composition of U.S. Coinage in circulation" at this time.

3.2. National Armored Car Association

Utilizing the CTC report, industry-specific information, and the 2012 Biennial Report to Congress, NACA submitted recommendations and discussion points to be considered by the Mint as research and development continue. The issues of concern involved coin dimension, diameter, and thickness; electromagnetic signature; wrapping; weighing; vendor acceptance equipment; terminal equipment replacement costs; employee safety; and transition time.[9]

3.2.1.Dimensions of Circulating Coins

There are two primary pieces of equipment used to process coin at each of the 170 Federal-Reserve-contracted coin terminals, sorters, and wrapping machines. The high-speed coin sorters separate by denomination, based on size—diameter and thickness—and EMS. Once

[9] Exhibit # 6 National Armored Car Association, Comments in Response to U.S. Mint's Notice with Request for Comment, June 24, 2014, FRN response.

separated by denomination, coins are packaged by either wrapping or bagging; with coin bags verified by weight.

Automatic sorters are the primary method used for sorting coins. As noted in the NACA report, "they recognize the coins and push them through to the appropriate chute, resulting in separation of each denomination entered into the machine." Each machine is calibrated to recognize different coins. Should dimensions change, each machine would have to be upgraded and reprogrammed. While the CTC report indicated the costs of those upgrades and reprogrammings to be in the mid-$400K (gross) range, NACA believes that the costs would be considerably more, possibly exceeding $50K per machine, with each processing terminal utilizing four machines (a total of over $3.4 million).

Coin-wrapping machines are used after the sorting process to package denominationally separated coins. These machines depend on segregation of coins according to size prior to bagging. CTC reported that "changes of more than 1 percent to either diameter or thickness from incumbent coins would result in all 2,000 machines needing upgrades." NACA stated that changes of less than 1 percent would require retooling. CTC's cost estimate of $1.25 million for retooling is considered to be very low with NACA noting "the figure is much higher."

The CTC report noted that some NACA members maintain JetSort coin sorters and Glory coin wrappers. It is believed that it would not be possible to continue to operate this equipment, forcing the equipment to be replaced. These pieces of equipment are widely used throughout the retail industry.

3.2.2.Weight of Coins

According to NACA:

> *Altering the metal composition of coins would result in a change to the weight of coins. Such a change would not only force armored car companies to reprogram and redesign currently used machines but would result in other serious consequences, from decreasing productivity and output to increasing the volume of armored cars on the road and potential exposure to workplace hazards for employees.*

By using the weight-verification method, terminal operators save considerable time and expense as substantial efficiencies are recognized. A change in metal composition could impact coins' weight, which could result in out-of-tolerance process conditions. In this case,

operators would have to return to piece verification, a much more costly alternative. A heavier coin could impact other downstream processing, requiring replacement of skids, bags, bins, and forklifts, adding again to processing costs. Transportation and safety would further be impacted. All of these costs could not be absorbed and eventually passed on to the consumer.

3.2.3.Canada's Recent Transition

In April 2012, Canada unveiled a new generation of 1- and 2-dollar coins; the $1 coin remained a plated coin and the $2 coin was kept bi-metallic, but the material for both changed to multi-ply-plated steel (MPPS). While the equipment manufacturing companies referred to the Canadian transition as being well planned and not problematic, NACA noted that a number of their operators were not as complimentary. "Several of NACA's member companies experienced the problems that arose during the transition.

Transition Time

The CTC report noted that an appropriate transition time would be 2–3 years to prepare for new coinage. NACA felt this would be inadequate; a more realistic timeframe would be 5 years.

3.2.4.Summary

The National Armored Carrier Association (NACA) recommends no changes be made at this time to the sizes or metallic composition of current U.S. coins. The NACA does not believe the United States Mint should alter the currently circulating coinage. As the CTC report expressly states, the costs associated and born by the stakeholders would dwarf any savings realized by the Mint. In addition, NACA stated that altering the metal composition of coins would result in a change to the weight of coins.[10] Such a change would not only force armored-car companies to reprogram and redesign currently used machines, but would result in other serious consequences, from decreasing productivity and output to increasing the volume of armored cars on the road and potential exposure to workplace hazards for employees. NACA also expressed concern that an alteration of coins' weight could eliminate weighing as an option for bulk verification and significantly influence productivity.

[10] Actual testing of "seamless" materials indicates this may not be true.

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4. The Commerce Sector

The largest segment of responders to the FRN came from the commerce sector. This group is represented by associations, coalitions[11] and twelve independent businesses[12]. Their collective voices emphasized the cost impact to the small business person and the inability to withstand the change or to pass on to customers the increased cost associated with equipment upgrades.

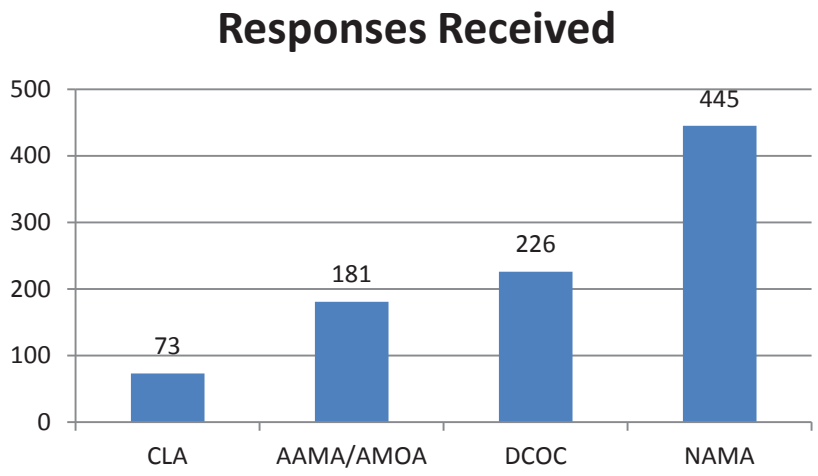
The eleven responding associations are:

- American Amusement Machine Association (AAMA)
- Amusement & Music Operators Association (AMOA)
- Coin Laundry Association (CLA)
- Canadian Automatic Merchandising Association (CAMA)
- International Parking Institute (IPI)
- International Association of Amusement Parks and Attractions (IAAPA)
- Multi-housing Laundry Association (MLA)
- National Automatic Merchandising Association (NAMA)
- National Bulk Vending Association (NBVA)
- National Council of State Agencies for the Blind (NCSAB)
- National Parking Association (NPA)

Don't Change our Change (DCOC) is a coalition of members from the above responding organizations. This coalition was formed during the March 13, 2014, Stakeholder Outreach meeting at U.S. Mint headquarters, and actively participated in the Federal Register request for industry comments.

In addition, the following four groups launched public information and education campaigns to encourage their members to respond to the FRN:

[11] Coalitions are independent business persons that responded as members of either one of the associations or the "Don't Change Our Change" coalition, formed during the March 13, 2014 Stakeholder Outreach meeting.
[12] Businesses that responded without declaring an affiliation with an association or coalition.



4.1. Associations

American Amusement Machine Association (AAMA) is an international, non-profit trade association representing the manufacturers, distributors, and part suppliers of the coin-operated industry. AAMA was founded over thirty years ago by a small group of co-operated machine manufacturers concerned with the future of their industry. Today, the AAMA serves its membership through legislative efforts, promotional arenas, foreign business development, and much more.

AAMA noted challenges with changing the composition as well as the metallic content of circulating coins. The estimated cost to upgrade each piece of equipment would be between $100 and $500. "It is estimated that there are approximately 1 million coin operated amusement machines in the United States."[13]

Amusement & Music Operators Association (AMOA) was established in 1948 by 68 jukebox owners from around the country who banded together to fight the repeal of the jukebox royalty exemption. Today, the AMOA is a diverse group of companies engaged in the coin-operated amusement industry. Members include those who own and operate machines such as jukeboxes, video games, pinball machines, and pool tables. Other members include suppliers of the industry, who provide parts or accessories, such as monitors, bill changers, and locks, as well as distributors who market in the industry supply chain. AMOA has approximately 1,000 members, which represent nearly 10,000 jobs.

[13] Exhibit # 7 American Amusement Machine Association, Coin Stakeholders Response, June 3, 2014, FRN response

AMOA noted "serious concerns" to the Mint, recommending changes to the composition of coins. "Any changes to coins will require expensive modifications to coin mechanisms by the coin operated amusement industry." AMOA went on to note that their experience with the Canadian transition was not as positive as others. "It was estimated the upgrades would cost the Canadian vending industry C$40 million to recalibrate what it calls coin acceptance equipment." AMOA said that "Changes in the metallic content of coins will cost coin-operated equipment operators between $100-$500 per machine in upgrade costs to accept new coins. With an estimated one million coin-operated amusement, music and vending machines in the United States, this equates to $500 million added cost to an industry dominated by small to mid-sized entrepreneurial owners."[14]

Coin Laundry Association (CLA) was established in 1960 to ensure a profitable and growing retail, self-service, laundry operation by providing superior education, products, and services to laundry owners. The coin-laundry industry is made up of more than 20,000 small business owners operating 30,000 self-service laundries throughout the United States; approximately 27,000 of these laundries accept the quarter for payment.

CLA requests that the quarter remain unchanged. "To replace and update these coin mechanisms with new ones designed to accommodate newly constituted quarters, along with legacy quarters, would put an enormous financial burden on the shoulders of mom and pop laundry owners across the country." CLA noted that 90 percent of all transactions are conducted with quarters. It was further noted that "Our laundries provide a basic health service to more than 7 million families each week. These families are often among the lowest income members of the community and can ill-afford increases to the costs of doing laundry."[15]

Canadian Automatic Merchandising Association (CAMA), established in 1953, is the only association representing the interests of Vending Operators, Machine Manufacturers, and Product & Service Suppliers in Canada. CAMA services are designed to represent, support, and enhance the vending, office-coffee, and food-service industries.

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[14] Exhibit # 8 Amusement & Music Operators Association, Response to request for comments on potential alternative metal compositions for circulating coinage , June 25, 2014, FRN response

[15] Exhibit 9 Coin Laundry Association, Stakeholders Response, June 18, 2014, FRN response

CAMA said that "As the Canadian public has experienced several currency (Coin and Bank Note) changes over the past 18 years, there has been 3 distinct coinage change events, in 1996, 1999, and 2012." CAMA explained that:

> *The Canadian unattended business segment has bore all the cost of these changes, with some companies not being able to manage the conversion costs, resulting in bankruptcy or the sale of their business. This was reported during or shortly after mandated coinage changes in the 1990's. The primary reason was associated to antiquated or less sophisticated coin recognition technology, which dictated the replacement to more modern electronic devices or the need to send those less sophisticated devices in for servicing, leaving machines out of order for several weeks, at a time. This had a significant impact on revenue earned by the business owner which limited cash flow and drove down the flexibility of their business to grow for a few years.*[16]

International Association of Amusement Parks and Attractions (IAAPA) represents more than 4,500 facilities, suppliers, and individual members from more than 90 countries. In the United States, IAAPA has members in all 50 states. Member facilities include amusement and theme parks, water parks, attractions, family entertainment centers, arcades, zoos, aquariums, museums, science centers, and resorts. Currently IAAPA estimates that the attraction industry in the U.S. employs 1.275 million people and it has a total economic impact of $91.4 billion.

IAAPA said that:

> *To date, no mechanism exists that can accept and process coins with different electronic signatures. Until this technology is created, operators and consumers will experience faulty machines. It is not out of the realm of expectations to assume that should breakdowns frequently occur, machines will be pulled from service, hurting business owners and limiting consumer choice.*

IAAPA noted that "Any change to coinage will result in increased cost to update equipment and address issues with co-circulation of the old and new currencies. These costs may affect

[16] Exhibit 10 Canadian Automatic Merchandising Association, US Mint Coinage Change, June 9, 2014; FRN response

the attraction's industry's ability to grow and create jobs." IAAPA says that "there is no return on investment for these equipment upgrades.[17]

International Parking Institute (IPI) is the world's largest organization representing the parking industry. The association's diverse membership is comprised of organizations managing, owning, constructing, and operating parking programs in the United States and in 46 other countries. IPI membership includes municipalities, academic institutions, healthcare facilities, transportation agencies, entertainment facilities, parking-equipment manufacturers, and many others. The U.S. parking industry generates over $30 billion in annual revenues.

IPI is concerned over potential changes to the composition of new coins relating to content, weight, dimension, and EMS. Specific concern was raised regarding conversion costs, "Not knowing the actual changes being considered to U.S. coins, it is estimated that retrofitting parking meters could cost $200–$300 per machine excluding labor." IPI stated that the burden for the parking-meter owners, both private and municipalities, could exceed $400,000,000.

IPI further stated:

> *Due to the significant number of parking meters that would require retrofitting to recognize both new and old coins, the parking industry requests three to five years to implement and upgrade our industry's equipment should a change be made to U.S. coins. Because, in many cases, revenue generated by parking management supports many other government functions (police, fire, emergency rescue, road maintenance), this transition period would also benefit the cities and local authorities to allocate their costs and adjust their budgets to minimize any disruption to service over a longer period of time.*

Multi-housing Laundry Association (MLA) is a trade association that represents the laundry service companies that operate laundry machines in central laundry rooms in multi-housing dwellings, such as apartment buildings, college dormitories, and military bases. MLA's

[17] Exhibit 11 International Association of Amusement Parks and Attractions, Notice with Request for Comment on Effects of Changing the Metal Composition of Circulating United States Coinage, June 20, 2014, FRN response

member companies and other companies purchase and install washer and dryers in central laundry rooms throughout the United States.

MLA said "that if the quarter is altered in weight or electromagnetic signature, MLA believes that coin acceptance devices in the 1.8 million machines in central laundry rooms that now receive coin payments would need to be replaced." The estimated total cost to the entire industry would total $360 million." This amount would be increased if the Mint chose to use a co-circulate option for the quarter. "Given the very substantial disparity between the savings to the Mint and the costs that any change in the weight or electromagnetic signature of the quarter coin would impose on MLA's members other companies in this single industry alone, MLA strongly opposes any such change."[18]

National Automatic Merchandising Association (NAMA) founded in 1936, is the association representing the $42 billion U.S. vending and refreshment services industry. With 1,800 member companies—including many of the world's most recognized brands—NAMA provides advocacy, education, and research to its membership.

NAMA reminded the Mint that the Act requires consideration be given to the impact on vending. The NAMA feedback indicated the most significant potential impact of a change to circulating coin composition would be to those industries that use machines that accept coins for automated payments. These machines rely on acceptors that discern the EMS, weight, and shape of each coin to identify its value. NAMA estimates there are seven million vending machines across the country and the cost of these changes could amount to $3.5 billion for the vending industry, negatively impacting the entire vending and food service channel and its consumers.

Other concerns raised by NAMA include:

1) Canadian experience: "Canada's just-released new loonies and toonies—its $1 and $2 coins—are slightly lighter than the old ones. And that's causing a lot of headaches (and expense) for vending-machine operators and city governments who have to recalibrate their coin slots and local parking meters;"
2) Co-circulation: "NAMA strongly recommends that any recommendations for changes in coinage include that there be no co-circulation of different specification coins of the same denomination;" and,

[18] Exhibit 12 Multi-housing Laundry Association, Stakeholders Response, June 12, 2014, FRN response

3) Cost to Federal Government: "If upgrades to coin acceptance equipment have a $1 billion cost to business, the U.S. Treasury's tax revenue will decrease by the amount of corporate tax it would collect on the $1 billion in revenue. This cost to the government should be considered in any cost-benefit analysis performed."[19]

National Bulk Vending Association (NBVA) is a national, not-for-profit, trade association comprised of the manufacturers, distributors, and operators of bulk vending machines (such as gumball machines) and products. The NBVA has represented the bulk vending industry since 1950. Its members extend beyond the borders of the United States and represent a great majority of the volume of the bulk vending business done in the United States. According to NBVA "Among their purposes, are to act to preserve and protect the bulk vending industry from detrimental legislation."

NBVA shared that as an industry, they oppose changing the composition of the quarter-dollar (quarter). Specifically NBVA said that "changing the quarter's weight, magnetic signature, or size would have immediate and devastating impacts on the bulk vending industry. Bulk vending machines have mechanical mechanisms, or "mechs" in industry parlance, that collect coinage and dispense product. The mechs are manufactured for the specific size, shape, and material content of specific coinage. There are millions of coin mechs being used today from car washes to bubble gum machines." They went on to note "nearly all bulk vending machines in the United States rely on the quarter as their sole currency and changing the composition of the quarter would make all their machines obsolete as their current coin mechanisms could not accommodate a new coin." In summary, "the NBVA pleads that we not change the composition of the quarter estimating the change would cost $41,238,000; which could cost jobs and destroy an iconic American industry."[20]

National Council of State Agencies for the Blind (NCSAB) promotes through advocacy, coordination, and education the delivery of specialized services that enable individuals who are blind and visually impaired to achieve personal and vocational independence.

NCSAB support the Randolph-Sheppard Act which provides entrepreneurial opportunities to blind vendors in the food service industry. According to the NCSAB, "Nationwide, there are 2,545 blind vendors participating in the Randolph-Sheppard program. These vendors operate 3,031 facilities on federal and state property. Most of the vending facilities in the

[19] Exhibit 13 National Automatic Merchandising Association, Stakeholders Response, June 17, 2014, FRN response

[20] Exhibit 14 National Bulk Vending Association, Coin Stakeholders Response, June 17, 2014, FRN response

Randolph-Sheppard program include small "mom and pop" operations, with include one or two full-time employees in addition to the blind entrepreneur." The NCSAB believes that the vending industry would suffer much greater financial consequences due to conversion cost than the U.S. Mint estimates. NCSAB states that "The Mint estimates that a one-time, standalone conversion of the nation's vending machines could cost between $380 and $630 million. The vending machine industry, however, estimates a nationwide conversion cost ranging from $700 million to $3.5 billion." Additionally, NCSAB noted "that Changes to U.S. coinage could adversely impact the ability of the blind or visually impaired to distinguish coins by touch. Certainly, the Mint is aware of and is working to comply with the October 2008 ruling by the U.S. District Court for the District of Columbia that the Department of the Treasury must provide meaningful access to U.S. currency for the blind or visually impaired. Changes in the metal composition and design of coins have important implications for the visually impaired community."[21]

Additionally, two state delegates from the State of Georgia responded to the FRN on behalf of their constituents who rely on the Randolph-Sheppard program. Both letters noted the hardship a change of this nature would impose on these small business persons.

National Parking Association (NPA) is the nation's leading trade association, representing 2000 members and advancing the interests of public and private sector parking leaders and professionals.

NPA provided feedback relating to small business owners as well as public entities. NPA noted

The parking industry would be particularly disadvantaged by changes the majority of commercial operators are small to medium sized, privately held firms. These companies would be faced with costly decision to automate operations, or even close their doors. For larger operations, both public and private, the cost of new equipment, training, software, and changes to business systems across their operations would be a financial and operational burden."[22]

NPA gathered member input and surveyed its members and found the following:

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[21] Exhibit 15 National Council of State Agencies for the Blind, Impacts of altering the metal composition of circulating United States coinage, June 9, 2014, FRN response

[22] Exhibit 16 National Parking Association, Coin Stakeholders Response, June 24, 2014, FRN response

- Industry suppliers would require 3–5 years to recapitalize operations, develop, and roll out new equipment.
- At a minimum, it would take parking operators (public and private) five years to plan, budget, and transition monetary metals—including securing capital, training staff, and upgrading equipment.
- To offset the cost of adopting changes in monetary metals, 50 percent of respondents reported that they would reduce staff and 55 percent would raise prices by up to 25 percent.
- 100 percent of respondents accept quarters.
- 91 percent of respondents accept nickels and dimes; 87 percent accept dollar coins; and 52 percent accept half dollars.

NPA does not recommend making any changes to the composition of the quarter as this would have the greatest impact to businesses. NPA supports the use of alternative metals, with a stipulation: "If changes can be made to monetary metals that allow for continued acceptance in existing equipment, this would significantly reduce the burden of any changes in monetary metals."

Additional Associations--Members of three additional associations submitted signed letters which noted the potential negative impacts on their members' industries. These three associations are AAMA,[23], NAMA[24], and AMOA[25].

4.2. Coalitions

The Mint received 226 copies of a letter from DCOC members, demonstrating a strong, united front. The coalition's letter specifically stated, "Changes to coinage will create an added expense, at best, and could mean the difference between thriving or failing business for many coalition members." The letter further noted that there are approximately 10 million coin-operated machines currently in existence nationwide, which could require a retrofit for new coins at a cost of $100–$500 per machine.

DCOC said that further impacts would include:

- Unknown consequences of co-circulating new coins

[23] Exhibit #18 AAMA (note the text of the AAMA and AMOA are very similar as these two organizations have overlapping constituents and memberships)
[24] Exhibit #19 NAMA
[25] Exhibit #20 AMOA

- Uncertainty associated with the length of a transition period
- Increased service of equipment
- The savings recognized from the composition change would be offset by a reduction in tax revenue[26]

4.3. Other Small-Business Owners

There are twelve unaffiliated business persons that provided input. Additionally, a number of small businesses provided specificity on how their operations would be impacted; examples are included in the emails copied into exhibit 21.[27]

4.4. Other Industry Input

The Stakeholder Outreach group engaged and solicited input from the retail, grocery, big box, car wash, amusement parks, coin processors, and public transit business sectors via conference calls, webinars, and face-to-face meetings. Collectively, there was an expression of caution from those contacted. They encouraged Mint personnel to work to become aware of the interdependencies of processing systems and the potential "cascading impact" of what some might consider a minor change. Changes to the weight, dimension or EMS could require significant investment which would not provide for further efficiencies. In addition to upfront investment, handling and processing costs would likely increase. The gains forecasted by the bureau in the CTC report would be dwarfed by the cost to industry.

4.5. Summary

The message from all sectors is clear; these groups voiced concern over any change, noting that the societal impact from a cost perspective could far exceed gains recognized by the Mint. One contributor requested that the financial analysis consider the direct reduction in tax receipts stemming from the required capital outlay multiplied by the business tax rate. The general vending community (parking, laundry and amusement association representatives and their constituents' as a minimum baseline) reiterated specific mention of the importance not to change the quarter.

The manufacturers of processing equipment focused on transition time as equipment replacement and servicing their customer base would prove to be exceedingly challenging if there were an uncoordinated cutover to a alternative. The total cost estimate of the societal

[26] Exhibit #17 Do Not Change Our Change, Coalition letter, Received 226 copies over 5 weeks, FRN response
[27] EXHIBIT 21 Compilation of select emails received from small business persons.

impact range from $2.46B to $5.0B. Some submissions were omitted as they represented potential double accounting. Association Societal Cost Estimates for capital improvements excludes ongoing recurring cost increases such as decreased throughput and newly introduced incumbencies.

What the bureau may take from this input is the understanding that a co-circulate option may offer more savings in materials, but those savings could be partially or wholly negated by the societal costs. As a result, "seamless" alternatives[28] (which could have lower savings in materials) are a superior choice for the Nation's circulating coins.

[28] "Seamless" refers to those materials that have a matching EMS and piece weight with the current coins. Two such materials were tested in Phase II, and more were identified for testing in Phase III, with even better potential savings.

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5. Appendices

5.1. Cashmaster, Inc.

U.S. Proposed Coin Change

Cashmaster International Limited

U.S. Proposed Coin Change – Discussion Paper

Cashmaster International Ltd. Page **1** of **7**

This paper is in response to the Notice With Request For Comment by the United States Mint, included in the Federal Register, for comments on potential alternative metal compositions for circulating coinage pursuant to the Coin Modernization, Oversight, and Continuity Act of 2010 (Pub. L. 111-302).

What is being considered?

The U.S. Mint is considering a change to the composition of metals it uses to make the quarters, dimes and nickels. The Mint's motivation for this change is to reduce the expense of manufacturing these coins which cost the Mint nearly as much or more to manufacture and distribute than the face value of the coins. For example, the cost to the Mint of producing the nickel is 9.4 cents – losing the Mint 4.4 cents on every nickel produced.

If the Mint proceeds with its plans, new coinage would enter circulation in the next few years having different properties compared to the existing coinage. These coins might have a different hue (i.e. color), have a different electromagnetic signature, or be lighter in weight, or even have different dimensions.

What are the implications of this proposal?

Across America, coin acceptors installed in vending machines, laundromats, parking meters etc. could refuse genuine American coins until the businesses affected invest in upgrades.

The financial outlay necessary to resolve this circumstance would bring no return on investment to these businesses except to be able to continue to accept circulating U.S. coins. According to the Mint's own report to congress, modifying vending machines to accept coins with a different electromagnetic signature but having the same size and similar weight as the existing coins could cost industry as much as $3.5 billion. Although the Mint would wish to minimize the burden of any change, it is certain that the cost to industry would greatly exceed the savings realized by the Mint.

Affecting even more businesses are the consequences of any such change on their coin counting, sorting and verifying processes and equipment. Equipment used to count, sort or verify coins may also have to be upgraded or replaced. Upgrading equipment would be a burdensome expense for businesses; replacing equipment would involve much larger procurement costs. Where direct replacements are unavailable, further cost could be incurred for computer system integration.

Whatever the actual amounts, the costs for American businesses would be significant. Money earmarked for sustaining or growing business would have to be diverted towards preparing for the new coinage. Inevitably job losses and business closures would occur as a direct result.

Some of our customers who will be directly affected by change to coin weight :-

Our special concern with the proposals

We, Cashmaster International Ltd, are a global manufacturer of combined note and coin weighing equipment; our customers include some of America's largest retailers, restaurant chains, and other businesses requiring an affordable solution to counting cash on their own premises. Unlike other types of coin counting solutions, Cashmaster's solutions are lightweight, portable and are applicable to counting notes, coins, tokens and many other types of media.

Our popular Sigma 105 product, for example, is approximately 2lb in weight and has a capacity to weigh up to just over 3lbs of coinage. As a weigh counter, the Sigma 105 calculates the number of coins placed on it by dividing the total weight by the average weight of the denomination. This technology is quick, robust and offers advantages that other cash handling equipment can't – such as the ability to count wrapped coins.

A typical deployment of our technology is for till drawer reconciliation on a retailer's shop-floor. Cash reconciliation operatives will carry one of our products from till to till, using it to count everything in the till drawer as they go. Instead of moving heavy till drawers, they can move our lightweight technology to where the cash is. This saves time and also reduces the probability of worker compensation claims for lifting injuries. Other cash counting solutions are either too heavy to be portable or focus on only one aspect of counting.

The problems of co-circulation

The crucial requirement for the weigh counting method is a standardized coin weight. Co-circulation of coins having different weights is ruinous for coin weighing technology as co-circulating coins would have to be separated for counting. The productivity gains currently enjoyed by Cashmaster's

customers would be largely negated by co-circulation of old and new coinage. No software upgrade, nor hardware upgrade, of our products can resolve this issue. Also it is not possible to easily discriminate between the new and old coinage, it would be impossible to employ weigh counting technology for accurate counting.

At present the U.S. Mint allows the co-circulation of the one penny coin and has done so since 1982. Pennies issued between 1909 and 1982 weigh 3.11g each; pennies issued between 1982 and the present day weigh 2.50g each. Thirty two old pennies therefore approximately weigh the same as twenty-five new pennies. Using a weigh counting machine, the best that can be achieved is an estimate of the number of pennies on the scale platform. Despite this, weigh counting operators have realized that the benefits of weigh counting are too great to ignore. The low value of the penny coin compared to the other coins has kept weigh counting as a viable method.

Co-circulation of higher value coins with different weights would make coin weighing technology untenable. This would be an ongoing damaging consequence of co-circulation.

What can you do to stop this?

AMERICAN DEALERS TO CONTRIBUTE TO THIS SECTION OF THIS DOCUMENT.

Who should be contacted? Commercial customers, Legislators, Congress? Other actions?

Conclusion

If the United States Mint proceeds with its proposal to change the coinage, there would be adverse direct consequences for many significant U.S. based retailers, the many thousands of American jobs which are supported by our business, and the wider American economy.

U.S. Proposed Coin Change – Discussion Paper

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5.2. Coin Mechanisms Inc.

COIN MECHANISMS INC.

Innovation Through Technology

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www.coinmech.com

16 June 2014

Coin Stakeholders Response
Office of Coin Studies
United States Mint
801 9th Street NW.
Washington, DC 20220
Coin.StakeholdersResponse@usmint.treas.gov

The quarter coin has been the workhorse of circulating coins in the coin-op world. At the current cost of goods, the dollar coin could become the next most used coin in the coin-op industry. This will only happen if the Treasury eliminates the paper one dollar currency. Eliminating the one dollar paper currency can save the Treasury millions of dollars a year and allow the Mint to leave the quarter and one dollar coin as is or as close to its current EMS signature as possible. If savings in coin production are necessary, the remaining coin denominations could be more viable to significant changes that would save cost in production of those coins.

Coin Mechanisms Inc. manufacturers both mechanical coin acceptors as well as electronic coin acceptors. Our products are used in a varied coin-op industry including Gaming, Amusement, Car Wash/Services, Vending, Transit, and other coin-op machines.

A mechanical coin mechanism relies heavily on coin diameter, thickness, weight, and the alloy mix. A significant change to any of these parameters would necessitate a new and separate coin mechanism because it would be very difficult or impossible to accept co-existing coins in the same mechanism. Visual changes such as plating color or stamping relief in the artwork typically do not affect operation of a mechanical mechanism. The reeded edge around a coin should remain on any new issue replacement coin, for some mechanical mechanisms detect this reed edge and separate a smooth edge coin of the same size. It is favorable the Mint dropped the Aluminum alloy in the study, for coins/tokens made from aluminum do not flow well through a mechanical mechanism.

If a current non-ferrous coin is re-introduced as an alternate coin with some degree of ferrous metal (iron) in its alloy mix, it will now have “magnetic” properties and be affected to differing degrees by the magnet in a current mechanical mechanism. The magnet installed in most mechanical mechanisms used on copper based coins such as the quarter and dollar performs a dual function. The magnet will attract any ferrous based coin/token/fraud and will not let the coin pass and has to be wiped from the magnet using the reject lever built into the mechanism. More importantly, when the copper based coin passes the magnet, an eddy current is created within the coin when the copper based material is moving through a strong magnetic field. The induced electromagnetic magnetic field in the coin bucks the stationary magnetic field and thus slows the speed of the moving coin to direct it to a proper path of acceptance or rejection depending on the amount of copper or ferrous material within the coin.

Therefore, if a ferrous based coin was introduced to coexist with a copper based coin, a conventional mechanical coin mechanism would not be able to accept both coins without greatly sacrificing its ability to reject many fraud coins. So two mechanisms each designed to accept the unique coin would be needed or one mechanism designed to take both at a cost of accepting many frauds.

Our electronic coin mechanism called the Coin Comparitor and “Comparitor” series of mechanisms operates using a unique comparing circuit unlike most electronic coin acceptors. The Comparitor uses an actual physical coin or token that is placed within a set of coils in the device. This “resident” coin is used as the reference coin to compare to. The resident coin also sets up a diameter sizing slot for the Comparitor to accept coins of that diameter. The comparing circuitry and resident coin will only allow a deposited coin to be accepted if its EMS signature or mass and conductivity “match” the resident coin. When an EMS match occurs, and instantaneous circuit null occurs, opening a gate to allow the deposited coin to be accepted. There are no look-up tables or memory cells used to store and validate a coin(s) as in most coin devices. The validation in a Comparitor is instantaneous. This allows the Comparitor to validate coins at a very high rate of speed which was very desirable in the Gaming Industry.

The Comparitor cannot compare two different EMS signatures with one set of coils. Multiple sets of coils each housing a different resident coin would be required to accept coins of different EMS signatures if they were to coexist for currency. Using multiple sets of coils to do this would require a complete re-design of the current Comparitor from how it has existed for many years. A re-design would be a drastic financial undertaking that is not desirable or possible at this time.

Any change to coinage, particularly the quarter and dollar coins will result in increased costs to not only the manufactures of the coin devices but also the makers of coin-op machines, the businesses who use these machines, and finally to the customer who buys the products from these machines. It will be very difficult for any of these groups to recoup the losses they may incur for; transition updates, difficulty in co-circulation of two different coins with the same value, fraud introduction if a more common and cheaper alloy is chosen, and vandalism from disgruntled customers who do not understand the problem using a machine in “transition”. The latter introducing increased service costs to operators, and if we are to assume that machine breakdowns may occur more frequently with coexisting coins, machines pulled from service will hurt business owners and also limit consumer choices in using these machines.

The best recommendation we can give is to leave the quarter and dollar coins alone. If it becomes necessary to save cost in coin minting, the other denominations should be considered. An alternate way to save money is to eliminate the paper dollar bill which costs millions of dollars to reproduce because of its very short life span. This would allow the dollar coin to become more prevalent in day to day money transactions. Changing our coinage will be detrimental to many small businesses, operators, and manufacturers of devices related to this business. There is no return on investment for equipment upgrades which adds to business financial outlays and possibly leading to job losses in an economy that is trying to recover.

We appreciate the efforts the Mint is trying to save the government money. However, it appears changing our coinage may not be worth the effort in the long run if it ultimately kills jobs, punishes small business, angers consumers, and becomes an added expense to Americans as well as the government.

Regards,

Joe Ferrantelli

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5.3. Cummins-Allison Corp.

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June 3, 2014

Coin Stakeholders Response
Office of Coin Studies
United States Mint
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Washington, D.C. 20220
Coin.stakeholdersresponse@usmint.treas.gov

Dear United States Mint:

This letter is in response to your Request for Comment notice which was published in the *Federal Register* on April 10, 2014. All of us at the Cummins Allison Corporation appreciate the opportunity to provide you with our views on prospective changes to United States coins.

Cummins Allison is a global leader in developing solutions that quickly and accurately count, sort and authenticate currency, checks, and coins. We also sell and service a broad array of automatic teller machines. With a 125 year heritage of leadership in technology and product innovation, Cummins Allison serves the majority of financial institutions in the United States and worldwide, as well as, retail, gaming, law enforcement, and government. Our products are sold and serviced by an extensive network of nearly 50 branch offices located in the major US cities. We also have wholly owned subsidiaries in Australia, Canada, France, Germany, Ireland, and the United Kingdom. In addition, we have a worldwide dealer network which sells and services our products in more than 70 countries. The vast majority of Cummins Allison products are designed, developed and manufactured here in the United States. Cummins Allison has a portfolio of more than 350 patents which are utilized to protect our intellectual property and support our research and development investments. A strong US patent system is critical to our business model and our ability to continue to manufacture our products here in the United States.

The commercial coin counting, sorting, and authentication products developed and manufactured by Cummins Allison are available in a variety of sizes and formats to accommodate the varied needs of our diverse customer base. For example, our smaller machines provide coin counting and sorting in retail operations such as McDonalds, Home Depot, and Safeway. Our larger machines, which process at a rate upwards of 10,000 coins per minute, provide the major US banks, armored carriers, the gaming industry, governments, and others with exceptional dependability and accuracy for high volume coin processing. We also have a complete line of self-service machines, for public use, in some retail and banking locations. These machines enable the public to count the coins they have accumulated or collected at home.

One of the most critical features of our equipment is the ability to not only count and sort coins at a high rate of speed, but to also authenticate and identify counterfeits while doing so. Cummins Allison has a sensor research and development division near San Diego which provides state of the art coin and currency sensor technology for our equipment. When incorporated into our machinery, these sensors enable our customers to identify, reject, and cull coins that are illegal or foreign.

Cummins Allison supports efforts by the U.S. Government to identify new cost saving efficiencies, including methods for reducing production, manufacturing, and circulation costs associated with coin or paper currency. As an intellectual property intensive engineering and manufacturing company, we understand the challenges associated with an effort to reduce costs while providing innovative solutions, maintaining features and product quality. Often this is not an easy endeavor.

Over a period of many years, Cummins Allison has witnessed a variety of coin changes initiated by a number of countries. From our perspective, some changes have gone well and others have not. Based on our experience, we would like to offer the following points:

- The US penny has been through a number of changes since inception. Most of these changes involved alterations to the metallurgical content; the diameter and thickness was maintained. While all stakeholders were impacted by these changes, the implementation and transition to the new design was smooth, seamless, and of little impact for Cummins Allison products.

- Other countries have made changes to their coins. For example, not too long ago The Bank of Canada announced changes to the Canadian $1 and $2 coins. The changes were primarily to the coin material. The diameter and general appearance did not change. Implementation of the coin changes was not difficult for Cummins Allison, namely because the Canadian Mint routinely consulted with industry and other stakeholders to ensure their decisions were industry compatible.

- The introduction of low denomination coins in Mexico several years ago is an example of how a good intention to reduce the cost of coin manufacturing led to an undesirable result. With little to no industry communication and consultation, Mexico made changes to a number of their coins. In one instance they introduced a new coin that was the same size as an existing coin of a different value. Since many coin processing equipment manufacturers, including Cummins Allison, use coin dimensions to count and sort coins, the industry could not accurately process the new coin, or differentiate from an existing one.

  Machinery manufactured by Cummins Allison can accommodate and process coins which contain varied metallurgical properties. It is much more difficult and expensive, however, to alter or retrofit machinery that will accommodate new or changed coins which have a different diameter or thickness. Changes to diameter or thickness may require significant, expensive changes to our equipment, or the outright replacement of equipment.

- Coin metallurgical content changes can impact how well a machine functions or the life of the coin. Not too long ago, this consideration was neglected in Japan. A very soft, all aluminum coinage was introduced creating expensive equipment and coin durability problems. In short, the metallurgical content of coins can impact a coin's durability. While coin manufacturing cost savings can occur with use of less expensive metals and methods, these savings will not be fully realized if the coins are not durable, or they cause equipment to fail, or deteriorate prematurely.

  In addition, in order to provide a high level of security the design of the coin, including the dimensions, construction and metallurgical content, must be unique to every other coin in the world. For example, the United Kingdom has experienced a relatively high degree of one pound coin counterfeiting. The metallurgical properties of the current pound coin are nearly identical to coins from other countries that are significantly less in value. The United Kingdom has worked hard and is well on their way to addressing this matter. Importantly, their communication with Cummins Allison and other stakeholders about new technologies and potential changes to their coin set has been timely and thorough.

  Cummins Allison is not opposed to the co-circulation of coins, like the penny, of the same value but of different weights. Our equipment can manage most of these differences. Some coin processing stakeholders, however, use scales and weigh coins as a method of valuating large volumes. Coin content changes which alter the weight of coins would make this method of coin counting and bulk valuation difficult or impossible if different coins, of the same value and physical appearance, are co-circulated.

- Finally, it is critical to note that **any** alteration to coin design, content, or size can impact the ability of our machinery to process high volumes of coins both quickly and accurately. If coin design or material content changes are orchestrated hurriedly or without regard for our equipment and other stakeholders, the currently reliable US coin circulation infrastructure could be adversely impacted or fail altogether. To alter the size, design, or content of a coin without comprehensive consultation and coordination with our industry and others, could be disastrous for the American economy. In fact, a poorly conceived or implemented change could impact the worldwide integrity and value of American currency, disrupt public confidence and commerce, and cost the American government many, many times more than what might be saved as a result of the initial cost saving alteration.

  When introducing a new or altered coin, the transition must be nearly seamless for the coin circulation system and the public. While stakeholder input is essential for this to occur, stakeholder input will not help the process avoid critical issues if too little is requested too late. All stakeholders (banking, vending, armored carriers, retail, currency processors, government agencies and others that process and handle large volumes of coin and currency) must work collectively to fully raise and address issues that are vital to each and every component of the coin circulation system. Recently, Canada introduced new coins into circulation with ease and strong public acceptance. They were

able to succeed and achieve public buy-in because they fully communicated with and listened to all stakeholders early and often during the process… from conception through circulation.

For Cummins Allison, the ability to test and report on new material technologies or options, well prior to decision making, is very important. We would prefer to establish and maintain a strong partnership with Congress, the Treasury Department, and the United States Mint with the hope that all will benefit from the exchange of technical and marketplace expertise. Over the past several years, Cummins Allison has been working very closely with a number of Central Banks and Mints throughout the world to provide expertise and feedback in the development of new coins and banknotes.

If a decision is made to introduce a new coin in the United States, we strongly encourage the development of a government – industry/stakeholder task force, very early in the process, to generate a seamless transition. That would allow all stakeholders to carefully review options and alternatives from conception through circulation. This task force would help to assure that all technical, scientific, commercial and public issues are thoroughly addressed early on and at every stage of the process.

We would also like to suggest that any legislation to alter American coins contain a provision requiring all new or changed coins to have a significant level of counterfeiting deterrence technology. No American coin, regardless of value, should be susceptible to counterfeiting or be too similar to another world coin.

We appreciate and support your efforts, and those of Congress, to reduce the cost of American coin production and circulation. However, we encourage everyone to proceed slowly and cautiously when making any decision which changes the appearance, weight, size, or metallurgical content of our nation's coins. To achieve cost savings through new manufacturing efficiencies or coin content changes will mean nothing if the coins cannot be utilized or processed, and expensive societal costs are incurred. In addition, it is essential for new coins to contain a proper level of technology and uniqueness. U.S. coins that are susceptible to counterfeiting place our economic and national security at risk.

Thank you again for providing the Cummins Allison Corporation with an opportunity to comment on potential changes to United States coins. Please contact us if you have comments or questions.

Sincerely,

John Blake
Executive Vice President Engineering
Cummins Allison Corporation

5.4. Jarden Zinc Products

JARDEN zinc products
Unlock the Potential of Zinc
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June 9, 2014

Via Electronic Transmission

Coin Stakeholders Response
Office of Coin Studies
United States Mint
801 9th Street, NW, 6th Floor
Washington, DC 20220

RE: United States Mint Notice With Request for Comment To Supplement Information Regarding Alternative Metals for Circulating Coins

Dear Sir or Madam:

Jarden Zinc Products, LLC (JZP) is submitting comments to the Department of Treasury Notice With Request for Comments related to the Mint's intention of collecting information from coin industry stakeholders on the effects of changing qualities such as weight, color and electromagnetic signature of our circulating coins.

JZP is a metals and electroplating company that has been the U.S. Mint's penny supplier since 1981 and its sole source supplier since 1998. It is an international supplier of plated coinage products to more than 30 countries. Given our extensive expertise with a variety of mints around the world, JZP is in a good position to comment on alternative metals coinage changes. While the Mint is soliciting comment on five specific topics, Jarden will focus its comments on three of these items: color and visual changes, electromagnetic signature, and transition implementation.

There are acceptable lower cost alternative coin metals designs available on the market today and in use by a multitude of countries, often for their full range of denominations. Jarden makes these coins today for many foreign mints. The predominant product is plated coinage, which utilizes approximately 6% of the more expensive metals on the top surface, with 94% of the coin being much less expensive materials. Such technology is available and in use, being accepted by vending and coin counting equipment. Canada utilizes such coin design across its full range of denominations.

1. COLOR AND VISUAL CHANGES

Regarding color and visual changes to US circulating coins, electroplating technologies can achieve the typical coinage colors. These colors are achieved by utilizing a plating finish with the same color as the original coin. Our plated products are available in single or multiple layers, and a variety of colors and finishes, including:

- Copper
- Nickel
- Tin
- Brass
- Red Bronze
- Yellow Bronze
- White Bronze

Typically countries desire to maintain the same color as their more expensive existing coins. That is, we replace white or silver colored coins with an alternative white plated surface finish such as nickel, gold and yellow colors with a plated brass or bronze finish, and likewise red or copper coins with a plated copper finish.

As the Mint looks at new alloys for the 5-cent coin, including a copper-plated zinc alloy, cost savings would have to balance against public acceptance of a color change. Conversely, the 5-cent could retain its silvery color with nickel plating over a zinc or steel base.

Public acceptance falls into two categories - feel and look. There is a need for coins to "feel like money". For instance, aluminum coins the Mint tested were light, creating the perception of "play money" not worthy of its face value. When a new coin feels like "real" money, Jarden's experience has been the general public is not overly concerned with its composition, as long as they have confidence it works in transactions and doesn't look too different from the incumbent coin.

2. ELECTROMAGNETIC SIGNATURE/COMPETING INTERESTS

As noted, plated coin technology is quite common in the world today and has a proven track record of cost effectiveness and good performance in promoting day-to-day commerce. The desirability of copper, bronze, and nickel plating over a zinc substrate can be attributed to several factors including:

- Zinc is 8-10% lighter than typical circulation coinage materials, which also yields more pieces per pound or kilogram, making it more cost effective.
- Zinc based coins provide a very secure electro-magnetic signature as reported by Concurrent Technologies Corporation in the Mint's 2012 report to Congress. The report concluded that zinc based coins would be suitable for higher denominations. This is further reported in the May 2014 issue of Currency News, a leading industry magazine on currency.[i]
- Zinc based substrates require less plating than steel based substrates and with much better ductility of zinc, the coins are much less likely to experience corrosion problems as a result of damage during coining.

Under normal circulation handling, plated coins in general are very durable.

The Mint's stakeholder outreach and the views of industry stakeholders appear to be in conflict with the goals and purpose of The Coin Modernization, Oversight, and Continuity Act of 2010 (Pub. L. 111-302). It is difficult to make substantial reductions in the cost of circulating coins - which by definition will include plated coins or new alloys - and say there will be no effect on vending and amusement machines and commercial coin counting equipment.

On the one hand, the Mint and Congress can protect the status quo and defer achievable savings to the government through less expensive coins, thus avoiding any impact to the vending industry. Conversely, the Mint can pursue policies and lower cost technologies that work in most existing coin acceptance equipment, once re-programmed, and alleviate the coins' cost challenges.

Vending equipment relies on a coin's physical characteristics and electro-magnetic signature (EMS) to distinguish one denomination from another. The physical characteristics are rather easy to control. The metal or metals comprising a coin determine its EMS. A coin has an EMS whether it is solid alloy, multiple layers mechanically bonded together, or layers electro-plated onto an alloy.

Vending and counting equipment have the ability to distinguish a wide range of EMS profiles. Once a profile is established for a given denomination, the coin acceptor can be programmed to recognize it as such.

Obviously the challenge for the vending and coin acceptor industry would be the cost associated with such program changes. As with all equipment, over time there is the need for servicing. And as discussed at the March 13, 2014 Mint stakeholders meeting, should U.S. coins change materials, given a reasonable amount of time before release of the new coins, these industries could perform program changes during such normal maintenance activities, with much lower cost impact.

3. TRANSITION IMPLEMENTATION PERIOD/VENDING INDUSTRY ISSUES

The U.S. vending and amusement industries have raised concerns about the potential impact of any changes to coin or currency. These concerns are not unlike those mentioned by the Canadian vending industry early in the planned adoption of Multi-ply plated steel for Canada's $1 and $2 coins.[ii] However, the Royal Canadian Mint (RCM) worked closely with the vending industry to relieve those concerns.[iii]

The key factors in alleviating vending industry concerns appear to have been good communication between the RCM and the Canadian vending industry and sufficient time for the transition, including providing coin samples for testing and equipment calibration.

"Throughout 2010 CAMA represented our industry in frequent dialogue with The Royal Canadian Mint. Questions were raised regarding potential security issues, and consistent and reliable reading of the new multi-ply plated steel coins by coin mechanisms across the country. Release of the new one and two dollar coins was originally scheduled for late 2010 and then the first quarter of 2011. We are pleased to report that The Mint heard the concerns raised, and has confirmed their intention to allow the industry ample time to calibrate their machines prior to the launch of the coins, which is now expected to be early in 2012.

While no one likes the monetary costs associated with this initiative, it should be recognized that it is not unlike other business expense related to technological upgrades. In fact, on the subject of coinage, Canada has faired well with only two significant changes in the past 40 years, while other countries have experienced changes with far greater frequency.

In closing, we are particularly gratified to see senior management at The Mint encouraging stakeholders to "communicate directly with CAMA, as they have been working closely with us on this important initiative".[iv]

Like the RCM, the U.S. Mint and Congress could provide ample time for the vending industry and additional stakeholders including transit, telephone, parking, casinos and others, to test product and calibrate their machines.

With Canada's implementation schedule, CAMA cooperated with the coin alloy change and viewed any monetary costs equivalent to other technology upgrade business expenses.

According to CAMA President Kim Lockie, "The Royal Canadian Mint sought the input of CAMA and will ensure there has been sufficient time for testing followed by the necessary upgrade to coin acceptors by industry members." As per the Canadian Vending Magazine, CAMA was satisfied with how the Royal Canadian Mint worked with them on timelines for the new $1 and $2 coins, which hit the streets in early 2012.[v]

CONCLUSION

Several innovative approaches have been adopted by other countries, including plated zinc-based coinage and the Canadian Multi-ply steel coin, that include significant costs savings. We believe the potential savings to the Treasury associated with coin material changes will ultimately outweigh legislative emphasis on vending industry costs.

Jarden looks forward to working with the Mint to reduce the costs of circulating coins.

Sincerely,

Mark Blizard
Vice President

[i] Currency News, May 2014, Vol 12, No. 5, pg 1, "New Coins with Unique Electro Magnetic Signatures"
[ii] Canadian Vending Industry Upset with Coin Alloy Changes, Coin World, April 19, 2010, p. 68.
[iii] Modernizing Canada's Currency: Upcoming Changes to $1 and $2 Coins for CANA Members, Royal Canadian Mint Presentation, Updated October 5, 2010, pages 10 and 20
[iv] Canadian Automatic Merchandising Association Newsletter to members, February 2011, found at http://www.vending-cama.com/INDUSTRY/notices-Feb07-2011.asp
[v] Canadian Vending Magazine, Spring 2011, http://www.canadianvending.com/content/view/2557/136/

5.5. American Bankers Association

American Bankers Association

Building Success. Together.

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June 5, 2014

Coin Stakeholders Response
Office of Coin Studies
United States Mint
801 Ninth Street, NW
Washington, DC 20220

Dear Sir or Madam:

The American Bankers Association[1] (ABA) respectfully submits its comments to the United States Mint, regarding the Request for Comment (RFC) on developing alternative metal compositions for coinage in circulation on April 10, 2014. The RFC's intent is to gather information from coin industry stakeholders on the potential effects of changing the metallic composition of coins.

The U.S. Department of the Treasury (Treasury) is directed by the Coin Modernization Oversight and Continuity Act of 2010, Public Law 111-302[2] (the Act) to submit biennial reports to Congress to include an analysis of production costs for each coin in circulation, production cost trends, and recommendations for potential changes, including the introduction of new technologies in production to new metallic composition of coins. Treasury has delegated authority to conduct this research to the U.S. Mint. As part of this analysis, the U.S. Mint is required to consider the potential impact of any of these changes on merchants and other coin industry stakeholders. Upon consideration of the evidence and the options, ABA recommends no changes be made to the metallic composition of U.S. coinage in circulation at this time.

Discussion

The scope of the businesses that are considered coin industry stakeholders is very broad. It includes financial institutions, armored card services, commercial coin handling equipment manufacturers, municipal parking officials, tollbooth operators, laundromat owners, vending machine operators, and others. Changing the metallic composition of U.S. coinage would have a significant effect on these industries and their customers who would be forced to absorb increased expenses related to any changes.

Banks in the United States manage coins in different ways. Large banks may use a vendor, such as an armored card service, to provide coin related services including delivery and counting of coins. Other banks may perform the service "in-house" with their own equipment. Others may use some combination of both. But, in all cases, potential changes to the metallic composition of coins would result in increased costs to banks whether it is absorbed directly through equipment modifications or indirectly through increased fees charged by vendors providing coin services.

The RFC is asking for input on the potential effects of changing the weight, dimensions, color, and electromagnetic signature of coins in circulation. In addition, the RFC asks for comment on how much time would be needed to facilitate these changes if they are to be made.

Impact on Banks

Changing the weight or dimensions of a coin would present serious challenges to banks. Currently, bulk coinage is counted by weighing bags of coins. If the weight is changed in new coins in circulation they would need to be kept separate from coins issued earlier that are of different weights. For example, a bag of quarters with coins of mixed weights could not be counted accurately. Additional sorting would be required to put "old" quarters in one bag and "new" quarters in another. This would slow the counting process and would increase personnel costs if additional employees must manually sort the new coins from the old coins. There would also be costs if the "old" and "new" coins were separated through a new mechanical process instead of manual labor. Any alteration of the weight or dimensions of any coins would cause banks to incur additional expenses either by upgrading their own equipment and software or by paying increased fees to vendors that provide this service.

Changing the electromagnetic signature (EMS) of U.S. coinage would also affect the cost of handling coins. Counting and sorting equipment may use EMS to validate coin denominations. This is how most vending machines determine the value of coins presented for payment. Changing the EMS would require software programming upgrades to a very large number of devices beyond bank oriented coin service providers and vending machines, including parking meters, car washes, toll booths, and video games.

Changing the color of coins in circulation does not pose a significant challenge to the banking industry as long as the dimensions, weight, and EMS remain the same. However, color change would still require retraining employees of depository institutions to identify the coins and would require them to take more time to confirm the type of coins they are accepting for deposit or issuing in withdrawals. The cost of this type of retraining would be multiplied across all retail employees throughout the economy. A change in color may require more extensive consumer education to reassure the public that new coins are valid forms of payment.

Alternative Metals Study

To assist the U.S. Mint in its analysis, Concurrent Technologies Corporation (CTC) was hired to conduct extensive study of the potential cost savings to the U.S. government of producing coins with different metallic compositions as well as the potential expenses making these changes would have on the public. The 378 page "Alternative Metals Study"[3] was issued to assist the U.S. Mint prepare its Biennial Report to Congress on coin matters, and it provides a vast amount of data on the potential effects of changing from the status quo.
According to the study, if changes to coin dimensions are made the cost to upgrade 250,000 passive coin sorters/counters would be $62.5 million and could range up to $125 million.[4] Banks that perform their own coin sorting and counting internally will be required to upgrade equipment and absorb the cost directly.

Coin handling services are often provided to banks through armored car services. These service providers process coins based on weight so changes in that feature are most important. The study estimated that these service providers would incur increased annual costs of $21 million annually for counting nickels, dimes, quarters, half dollars, and dollars.[5] This is not a one-time cost for equipment upgrades but will be an ongoing expense. This expense will be passed on to these service providers' customers: banks.

An industry that would be powerfully affected by changes to coins in circulation would be large and small vending machine owners and operators. There are approximately 5.3 million vending machines in the United States.[6] The immediate out of pocket costs to large vending machine owners and operators for changing the dimensions of the quarter range from $668 million to $1.046 billion to upgrade existing equipment.[7] Similar expenses would be incurred for comparable changes to the nickel and dime. The study notes that these are significant expenses.

The CTC study makes several recommendations based on its analysis of the cost of coin production and the costs borne by coin industry participants. Among these recommendations are:

- Maintain existing coin dimensions for all future coins regardless of their materials for construction.
- Maintain the current composition of the one-cent and dollar coins.
- Consider alternative copper-based alloy changes for all other coins in search of a composition that would have lower production costs and that would minimize conversion costs to coin industry stakeholders with regard to changes in coin weight.
- Continue research and development efforts of metallic alloys that would mimic the current EMS signatures of the incumbent dime, quarter, and half dollar coins to avoid the need to upgrade coin processing equipment.

ABA supports these CTC study recommendations.

Transition Period

It is clear that any change by the U.S. Mint to the metallic content of coins would necessitate providing the industry a significant and appropriate time period to prepare in order to avoid any disruption in services and/or confusion for customers. Bank preparations would include software and hardware changes to any coin sorting equipment maintained "in-house." The amount of time required to make these changes would be contingent on what those changes were. Significant changes to the

weight, dimensions, or EMS may require a similarly lengthy implementation period. For these and other reasons, the banking industry opposes any such changes.

Many banks rely upon outside vendors to provide coin services. Those vendors would also need an appropriate amount of time to upgrade their equipment.

It is important to note that any potential changes would affect a broad number of industries and millions of coin-based devices and the consumers that use them. Looking beyond the scope of banks, there are 5.1 million coin operated laundry machines,[8] 2 million parking meters,[9] 300,000 car washes accepting coins,[10] and 60,000 public buses accepting coins.[11] Banks want to provide coins to customers that will work at all of the expected venues, including those mentioned above.

To implement such changes with a minimum of disruption, the U.S. Mint would have to allow adequate amount of time for *all* industries to upgrade their coin sorting and accepting equipment. It is our view that a transition period of 24-30 months beginning when test samples are provided would be necessary, adding additional weight to the view that such changes would not be worth the costs and difficulties imposed.

Conclusion

In conclusion, ABA supports the U.S. Mint's efforts to balance potential cost savings in coin production with the associated conversion costs for coin users. The research and outreach conducted by the U.S. Mint and CTC is extensive and demonstrates that changes to the current metallic composition of U.S. coinage is not currently achievable without increasing the costs of production and increasing the costs to coin industry stakeholders, especially to the hundreds of millions of users of U.S. coins. Neither of these outcomes is desired. Based on these findings ABA recommends no changes be made to the metallic composition of U.S. coinage in circulation be made at this time.

ABA appreciates the opportunity to comment on the U.S. Mint's RFC on developing alternative metal compositions for coinage in circulation. If you have any questions about these comments, please contact the undersigned at (202) 663-5147.

Sincerely,

Stephen K. Kenneally
Vice President

5.6. National Armored Car Association

VIA ELECTRONIC SUBMISSION

June 24, 2014

Director Jon Cameron
Coin Stakeholder Response
Office of Coin Studies
United States Mint
801 9th Street, N.W.
Washington, D.C. 20220-1234

Re: Comments in Response to United States Mint's Notice With Request for Comment, Docket ID 2014-08022, Published in the April 10, 2014 Federal Register (79 Fed. Reg. 19971)

Dear Director Cameron:

The National Armored Car Association (NACA) respectfully submits these comments to the United States Mint in response to the above-referenced request for comments, published in the *Federal Register* on April 10, 2014, at 79 Fed Reg 19971. NACA members request the Mint withdraw its consideration to alter the current coinage in circulation in the United States due to the significant costs of such changes to both the armored car industry and the economy as a whole.

Formed in 1929, NACA is a business association that brings together the four major companies of the armored car industry—Brink's, Dunbar, Garda, and Loomis—with a focus on protecting and promoting the common interests of the industry. Our members are national and international publicly traded corporations and privately held companies that provide secure transportation and cash management services for the Federal Reserve, financial institutions, state and local governments, and private businesses and individuals across the nation. These four organizations comprise approximately 90% of the armored car industry in the United States, and NACA members have handled virtually every dollar and coin in circulation.

The Mint has issued a Request for Comment regarding the potential use of alternative metals in the production of U.S. coinage in order to save money in the process. The Mint has requested input from the public and relevant stakeholders as to the consequences of changing qualities, such as weight, diameter, thickness, and electromagnetic signature, of currently circulating coins. While NACA understands the Mint's efforts with the proposal, changes to coinage will create a substantial burden and significant costs to the armored car industry, which outweigh any possible cost reductions in coin creation. Costs of upgrading or replacing current machinery as well as the resources necessary to establish and maintain a separation of the old and new coinage will significantly and negatively impact armored car companies' abilities to perform their duties for their clients. Operations will be slowed, resources will be diminished, and every institution or entity that employs an armored car company will be affected.

As indicated by the 2012 Biennial Report on the Current Status of Coin Production Costs and Analysis of Alternative Content issued in December of 2012 to Congress by the Mint, the costs associated with such changes will overshadow the potential savings the changes would bring to the Mint. Not only will the immediate economic impact of such a proposal be significant for the armored

car industry, but circulating in new coinage and out incumbent coins will take several years, creating costs, complications and burdens for armored car companies and their clients (including the federal government) for at least a decade if the rate of integration and replacement of circulating coins remains at its current rate of 3% per year.

As stipulated by the 2010 Coin Modernization, Oversight, and Continuity Act of 2010, the Mint contracted Concurrent Technologies Corporation (CTC) to study possible alternative metal compositions of US coins and research the possible consequences any changes could have on individual stakeholders and the economy as a whole. The resulting report, the Alternative Metals Study, submitted to Congress on August 31, 2010, provided the legislature, the Mint, and stakeholders with considerable data on the costs of the proposed changes to various stakeholders, including NACA members and their clients. Using the CTC report as well as industry-specific information and the 2012 Biennial Report, NACA submits the following information as evidence the Mint should withdraw consideration of altering the composition and size of circulating US coinage.

Costs Associated with Changes to the Dimensions of Circulating Coins

NACA member organizations and other armored car companies currently use two machines that will be significantly impacted by the proposed changes. In order to fulfill orders placed by clients, armored car companies need to separate all coins received at their coin terminals into separate denominations. This process involves the use of coin sorters, high-speed coin handling machines that separate coins based on both the size—diameter and thickness—and electromagnetic signature, into denominations. The separated coins can then either be shipped to clients in coin bags or entered into coin wrapping machines, which package a fixed amount of the same coins. These machines are vital to the industry, but the changes being considered by the Mint would require significant upgrades to or complete replacement of both the coin sorting and coin wrapping machines.

Coin Sorters:
Sorters are the primary method used by the armored car industry and other private and government entities for sorting coins. The machines use the coin's thickness and diameter to determine where the coin should be distributed. They recognize the coins and push them through to the appropriate chute, resulting in separation of each denomination entered into the machine. The CTC report estimated there are four such sorting machines at each of the two hundred Federal Reserve-contracted coin terminals.

Sorters are calibrated to recognize a specific number of different coins and to separate the coins by dimension. Should dimensions of coins change, armored car companies would be required to upgrade every one of these coin sorters and reprogram them to recognize the new dimensions. The CTC report estimates upgrades will cost $500 per coin sorter owned and operated by armored car companies, but NACA members expect the costs would be several thousand dollars per machine after taking into consideration the research and development also needed to accommodate the changes. While this would be a one-time cost, NACA estimates the cost will drain the armored car industry of hundreds of thousands, if not millions, of dollars (CTC estimates the costs will be between $160,000 and $400,000, but NACA believes the costs will reach well above this estimate).

These machines would also need to be adjusted to handle the larger variety of coinage, an issue that would arise from the co-circulation of both incumbent and new coins of the same denomination. Most sorters currently have six chutes, one of which is reserved for non-coins. If the Mint chooses to alter enough currently circulating coins, the sorters would no longer be operational due to the lack of

adequate parts to separate the quantity of coins. The armored car industry would need to replace these machines at a CTC estimated cost of up to $50,000 per machine plus research and development costs.

Coin Wrapping Machines:
Coin wrapping machines are used by the armored car industry to package coins already separated into denominations. The CTC report estimates there are 2,000 coin wrapping machines currently being used throughout the country. These machines currently have six to eight chutes through which coins are pushed to the appropriate section in order to be wrapped. The machines then rely on the coins' diameter and thickness to properly wrap the appropriate quantity of coins.

CTC's report analyzed the implications changes to the diameter and thickness of US circulating coins would have on the coin wrapping machines currently being used. They explained that changes of more than 1% to either diameter or thickness from incumbent coins would result in all 2,000 machines needing upgrades. NACA members believe that changes of even less than 1% would require a retooling, given the precision required for the coin wrapping machines. Every coin wrapping machine would need to be recalibrated to identify the appropriate quantity of coins to wrap and readjusted to increase the quantity of coin denominations the ATL can process at a given point in time. CTC's estimate for the cost of the coin wrapping machines' upgrades should the size of coins be changed is estimated to be between $250,000 and $1.25 million. NACA believes the figure is much higher.

Vendor Equipment:
NACA members also maintain some vendor equipment in their coin terminals. These machines, including but not limited to Glory coin wrappers and JetSort coin sorters, would also need the capability to handle any changes to circulating coins. It is anticipated that reprogramming many of these machines will not be possible, forcing the industry and their vendors to replace the machines entirely and resulting in a substantial cost to the industry.

All of the machinery in a coin terminal and used by NACA members would require upgrades, replacements, and substantial service to accommodate the changes. Such a strain on resources would force armored car companies to redistribute funds and resources, significantly limiting the organizations' abilities to fulfill their duties and responsibilities on behalf of their clients.

Consequences of Changing the Weight of Coins through the Use of Alternative Metals

Altering the metal composition of coins would result in a change to the weight of coins. Such a change would not only force armored car companies to reprogram and redesign currently used machines but would result in other serious consequences, from decreasing productivity and output to increasing the volume of armored cars on the road and potential exposure to workplace hazards for employees.

Weight Verification Method:
Currently used throughout the industry is a weight verification method which relies on the weight of a bag of coins of a specific denomination to identify the quantity of coins within the bag. A certain weight range, which is established by the U.S. Government, is tolerated in the calculation. The weight verification method frees up substantial amounts of time for the armored car industry by allowing companies to bypass the process of counting coins individually within each coin bag. The

process is used throughout the industry but will no longer be an option for armored car companies should changes be made to the metal composition and weight of circulating coins.

By changing the metal composition of the coins, bags of a certain denomination will contain both incumbent and new coinage, forcing armored car companies to consider a larger weight range to identify the quantity of coins in the bag. These ranges would be too large for an armored car company to accurately assess the quantity of coins in the given bag. The result would be the forced elimination of the weight verification technique, requiring armored car companies to count out every bag that enters their coin terminals and facilities. The loss of productivity and efficiency would slow down operations and lead to an increase in annual operating costs, hurting the industry every year. The industry cannot absorb these costs on their own and would have to be passed on to the companies' clients, including the government and banks.

Changes Needed for Equipment:
Changes to weight of circulating coin would require adjustments to coin sorters and coin handling equipment, such as fork lifts, bins, skids, and coin bags. Along with a coin's dimensions, sorters use the coin's metal composition to identify its denomination. Proximity sensors in the sorters detect changes to an electric field that is generated around the coin; this is the electromagnetic signature of the coin. If the Mint chooses to circulate coins of alternative metals, sorters will have to be reprogrammed to accurately identify and differentiate between the coins.

Heavier coins would also cause more wear and tear on all of the equipment, forcing armored car companies to update and/or replace machinery more quickly than is currently required. These consequences would result in a far larger demand on the armored car industry, hurting operations and the economy and forcing the industry to pass on the new costs to clients, including the federal government.

Transportation Concerns:
An increase in weight would also significantly impact armored cars' transportation costs. Many of NACA's trucks already reach the weight limit when carrying a standard order for a client. Should the weight of coins increase, trucks will only be capable of transporting smaller orders. Such changes will result in armored car companies' needing to use more trucks to carry the same quantity of coins. The heavier coins will result in substantially higher fuel costs and additional trucks on the road, impacting both traffic and the environment – the latter of which would be counter to federal policy to reduce greenhouse gases. Transportation costs would be significantly higher than is currently experienced. Heavier coins and more trips will take their own toll on the trucks, causing more wear and tear and leading to more common and more costly maintenance on the vehicles. These costs will be passed on to customers, including the federal government.

Safety for Employees:
Increases in weight add injury risk to employees of armored car companies. Heavier coins fall out of sorters, coin wrapping machines, and other coin handling machinery. The coins fall out of the drum, leaving operators and maintenance personnel at risk when trying to remove the coins and repair the machine. Such issues are already experienced by coin processing employees. Currently circulating nickels, which are heavier coins compared to their diameter, already fall through the machine, leaving employees at risk when attempting to fix the machines.

In addition to these risks, heavier coins could lead to injuries for employees who handle boxes and bags of coins during operations. Armored car companies would either be susceptible to and liable for

workplace injuries and would likely need to establish maximum weights for coin containers. Such a limit would lead to more coin containers as well as more employees needed to move the same quantity of coins, slowing down operations and possibly requiring additional employees. Once again, we can see that changes to coin composition and weight would easily lead to higher costs for the armored car industry and the clients who require their services.

Labor and Storage Costs to be Considered

Should the Mint decide to change any of the coins currently in circulation, the CTC report estimates at least one additional full-time employee making $50 per hour would be needed at every one of the two hundred terminals nationwide if diameter, weight, or both dimensions are changed. The estimated cost for these hires is expected to reach $21 million per year for the industry, a gross figure that would greatly diminish the armored car companies' resources and immediately depress their ability to hire new employees in other areas of their operations that are lacking adequate personnel. Even though the figure is substantial, NACA considers it a very low estimate and believes one fulltime employee would not be capable of the separation and sorting responsibilities at each terminal. More than one employee would be required at coin terminals, resulting in a far larger cost to the industry than the estimated $21 million annual payout.

The separation of denominations and incumbent versus new coins required during the transition period would decrease production and slow down operations. These space and separation requirements would overwhelm coin terminals throughout the country, many of which are already at their maximum capacity. Should new coins be introduced, the space necessary to prevent the coins from mixing would substantially increase the cost of maintenance and safety concerns for employees in the terminals. Some locations would no longer be able to serve as coin terminals for the Federal Reserve due to lack of floor space.

Experiences during Canada's Recent Transition to Steel-Plated Coins

In 2012 Canada introduced steel-plated one- and two-dollar coins into circulation. Several of NACA's member companies experienced the problems that arose during the transition. In order to successfully separate incumbent and newly introduced coins, one member had to modify the sorters to be capable of handling the transition. Currently the company has two coin sorters in Canada performing this function. The company did not have coin wrapping machines in operation at the time of the transition, so accurate assessments of the effects of the transition are not available.

Transition Time Needed to Accommodate for New Coinage

The CTC report recommended a two- to three-year transition period for relevant industries to prepare for the new coinage. NACA believes this would not be an adequate period of time to fully prepare machinery and operations for the introduction of new coinage. We therefore recommend that if the Mint does recommend any changes to the coinage, it extend the transition period to a minimum of five years. This would allow armored car companies the time to fully analyze any new coinage being introduced, comprehend the effects of the transition in its entirety, and identify and implement the least costly upgrades for machinery and restructuring of operations and personnel.

We also urge the Mint to include the armored car industry in the designing of new coinage and testing of the prototypes prior to publication of any final product. Armored car companies are vital to the free flow of currency, and excluding them from the process would invite unnecessary costs in

implementation. NACA members should have the opportunity to provide input to the Mint on the consequences, both positive and negative, of any coin that may be introduced.

The industry should have as much time as possible to adjust its machinery, operations, and personnel as needed. Should the Mint choose to move forward with new coinage, NACA recommends providing the armored car industry with a final product early in the process in order to have the most time possible to best adapt to the new coinage.

Conclusion and Final Thoughts to be Considered

The National Armored Car Association does not believe the United States Mint should alter the currently circulating coinage. As the CTC report expressly states, the costs associated and born by the stakeholders "would dwarf any savings realized by the United States Mint." CTC estimated a probable conversion cost of $1.45 billion, a figure that cannot be ignored in an already stagnant economy.

The armored car industry cannot handle the costs of the changes being considered. The changes will not only result in a one-time cost for machinery upgrades and reprogramming. As the report explains, the Treasury currently introduces newly minted coins into circulation at a rate of 3%, meaning the armored car industry, as well as every other industry that deals with coinage in daily operations, will be dealing with the costs associated with the transition for decades to come. More employees will be needed to sort out the new coins from the incumbents, count every coin bag that comes to the coin terminals, carry and move coin bags, and drive the necessary trucks to complete deliveries. Machinery in coin terminals and trucks on the road will be an annual concern and require maintenance on a more frequent basis. Space in coin terminals will be on short supply and increasingly larger demand. In conclusion the industry's costs of the transition will greatly diminish its resources and hinder its ability to fulfill its obligations to clients, including the federal government.

Based on the findings above, NACA recommends no changes be made at this time to the sizes or metallic composition of currently circulating US coins. We appreciate the opportunity to comment on the Mint's Request for Information and thank the agency for its consideration of our position.

Sincerely,

Jennifer Ortega
Manager, Government Relations
National Armored Car Association

5.7. American Amusement Machine Association

AAMA

AMERICAN AMUSEMENT MACHINE ASSOCIATION

Tuesday, June 3, 2014

Coin Stakeholders Response
Office of Coin Studies
United States Mint
801 9th St NW, 2nd Floor
Washington, DC 20001

These comments are submitted for the record to the United States Mint, on behalf of the American Amusement Machines Association (AAMA) in response to your recent request, included in the Federal Register, for comments on potential alternative metal compositions for circulating coinage pursuant to the Coin Modernization, Oversight, and Continuity Act of 2010 (Pub. L. 111- 302).

We appreciate the opportunity to comment.

The AAMA is a domestic non-profit trade organization representing the manufacturers, distributors, and part suppliers of the coin-operated amusement industry. AAMA was founded in 1981 by a small group of amusement coin-operated machine manufacturers concerned with the future of their industry. A Board of Directors, selected by its members, governs the AAMA. Committees work with the Association staff to develop programs to promote and protect the industry. Members donate their time, effort, and expertise on a voluntary basis. Today we have a staff of three who are responsible for the day-to-day activities of the organization as well as following the strategic direction set by our Board of Directors

Now in its 33th year, the AAMA serves its membership through legislative efforts, promotional arenas, trade shows coordination and much more. It is the AAMA's job to serve as the voice for these segments of the coin-operated and out-of-home entertainment amusement machine industry.

The coin-operated amusement industry has its roots in the city of Chicago. The first popular "arcade games" were early amusement park midway games such as shooting galleries, ball toss games, and the earliest coin-operated machines, such as those that claim to tell a person their fortune or played mechanical music. The old midways of 1920s-era amusement parks provided the inspiration and atmosphere of later arcade games.

In the 1930s, the first coin-operated pinball machines were made. These early amusement machines were distinct from their later electronic cousins in that they were made of wood, also they did not have plungers or lit-up bonus surfaces on the playing field, and used mechanical instead of electronic scoring readouts.

Today, a game (or coin-op) is a coin-operated entertainment machine, usually installed in public businesses, such as restaurants, bars, and particularly in family entertainment centers. Most games are video games, pinball machines, electro-mechanical games, pool tables, redemption games, and merchandisers. Furthermore, the industry encompasses the jukebox segment of the market. Across the United States there are over 200,000 coin-operated jukeboxes, ranging from the old 45's, CD's and the latest version, the internet Juke Box.

In addition to restaurants and family entertainment centers, these devices are also found in bowling alleys, college campuses, dormitories, laundromats, movie theaters, supermarkets, shopping malls, airports, ice rinks, corner shops, truck stops, bar/pubs, hotels, and even bakeries. In short, coin-operated games are popular in places open to the public where people are likely to have free time. The owners of this equipment, for the most part, are small family run, multi-generational businesses, located in every state across America. They are Main Street businesses.

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President's "E" Award Recipient

We estimate that there are over 1 million coin operated amusement machines currently in "play" in the United States. Today we believe there are over 250,000 coin-operated pool tables across the country. We estimate that these pools tables accept over 4 billion quarters each year. These pool tables will not accept two different types of quarters and thus, would become obsolete.

Changing the composition of coins will require expensive modifications to coin mechanisms by the coin-operated amusement industry. For example, if changes to the metallic content occur, this will require expensive reprogramming or replacement of most coin acceptors. Such reprogramming or replacement will require a technician to visit all the locations to service coin-operated machines and reprogram or replace the coin acceptors. Further, if mechanical changes are made to the coins, such as changes in sizes or weights, then even more expensive changes to coin acceptors will be needed. In almost every case, the coin acceptors will then need to be replaced at significant expense.

Our assumption is that the older coins will be kept in circulation for a period to time as well. This will lead to a much more time consuming and labor intensive process for sorting, counting and weighing the coin. This will affect the entire economy across the United States.

A change in the metallic content will also increase the risk of the fraudulent use of counterfeit coins ("slugs") or tokens in our machines, again leading to a loss in revenues.

Changes in metallic content would force coin acceptor manufacturers to increase the verification security level of coins thereby restricting and lowering the acceptance rate of the genuine coins to protect against counterfeiting or misreading of the coins. This could lead to customer dissatisfaction occurring by apparently good coins being rejected and revenues will be negatively affected by this rejection.

Changes in the metallic content of coins will cost coin-operated amusement machine operators between $100-$500 per machine in upgrade costs to accept new coins. It is estimated that there are approximately 1 million coin-operated amusement machines in the United States. This equals an estimated burden on the coin operated amusement industry of close to one half a billon dollars. Furthermore, this costly upgrade will provide no return on investment (ROI) for amusement machine operators. We anticipate this business financial burden will lead to job losses and for some enough to close their doors, thus having a negative impact on America's recovering economy.

We appreciate the underlying theme of this study; that the American government should look for ways to save taxpayers dollars. This notion is shared, not just by our members, but also by taxpayers across the country. Yet for our members and the industry we work in, proposed changes to the size and content of coinage will result in severe economic harm, for very little economic gain to the American taxpayer.

Thank you, once again for the opportunity to comment.

Sincerely yours,
American Amusement Machine Association

John Schultz, Executive Vice President

Pete Gustafson, President of the Board of Directors

CC: Board of Directors, AAMA

5.8. Amusement & Music Operators Association

This letter is in response to your recent request, included in the Federal Register, for comments on potential alternative metal compositions for circulating coinage pursuant to the Coin Modernization, Oversight, and Continuity Act of 2010 (Pub. L. 111- 302).

My name is Jack Kelleher, executive vice president of the Amusement & Music Operators Association (AMOA). I acknowledge the proactive outreach efforts the Office of Coin Studies has made during this process and appreciate the opportunity to provide input from my membership on the proposed changes to coin content.

AMOA was born January 21, 1948, when 68 jukebox owners from around the country banded together to fight the repeal of the jukebox royalty exemption. The modest beginning, created by a common cause, revealed the fierce passion that many of this industry's small business owners shared about their industry.

Today, the AMOA is a diverse group of companies engaged in the coin-operated amusement industry. Our product are jukeboxes, video games, pinball machines, pool tables, electronic soft tip dart boards, foosball, redemption and merchandising equipment, as well as other attractions activated by the insertion of coins, currency or other means of payment. Our members include: operators who own, place and service currency-activated equipment in a location; manufacturers of coin-operated equipment; suppliers of the industry who provide parts or accessories, such as monitors, bill changers, locks, etc.; and distributors who market and add value in the industry supply chain.

We have approximately 1,000 members across the United States. These members represent close to 10,000 jobs.

On the Mint's plan to recommend changes to the composition of coins, our industry has serious concerns. Any changes to coins will require expensive modifications to coin mechanisms by the coin-operated amusement industry. For example, if changes to metallic content occur, it will result in expensive reprogramming or replacement of most coin acceptors. Such reprogramming or replacement will require a technician to visit all the locations where coin-operated machines are operated and serviced. Further, if mechanical alterations are made to the coins, such as changes in sizes or weights, then even more expensive modifications to coin acceptors will be needed. In such cases, the coin acceptors will most likely need to be replaced at significant expense.

Changes in the metallic content of coins will cost coin-operated equipment operators between $100-$500 per machine in upgrade costs to accept new coins. With an estimated one million coin-operated amusement, music and vending machines in the United States, this equates to $500 million in added cost to an industry dominated by small to mid-sized entrepreneurial business owners.

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Furthermore, there is no return on investment for operators on such equipment upgrades. It simply places an added financial outlay that stymies investment in the enterprise, leads to job losses and ultimately hinders our recovering economy.

A change in the metallic content will also increase the risk of the fraudulent use of counterfeit coins ("slugs") or tokens in our machines, again leading to a loss in revenues

This, in turn, would force coin acceptor manufacturers to increase the verification security level of coins, thereby restricting and lowering the acceptance rate of the genuine coins to protect against counterfeiting or misreading of the coins. This will cause our customers—the users and players of our equipment—to become frustrated when apparently good coins are rejected. We cannot afford—figuratively and literally—dissatisfied patrons/voters.

And these revenue losses will not be confined to our businesses, but since we generally share our revenues with the locations where operator members place machines, there are literally hundreds of thousands of other small businesses that will be negatively impacted as well.

I ask you to look at the Canadian experience. In a cost-savings effort, the new Canadian coins used multi-ply steel technology, which makes them cheaper to mint than their alloy predecessors. It was estimated the upgrades would cost the Canadian vending industry C$40 million to recalibrate what it calls "coin-acceptance equipment." Changes to the metallic content of circulating coins in Canada have had a negative impact for many in the Canadian coin-acceptance industry. Following the Canadian coin updates, a May 2012 *Wall Street Journal* article cites the "headaches (and expense) for vending-machine operators and city governments who have to recalibrate their coin slots and local parking meters."

To put it bluntly, if you change the content of the quarter, the vast majority of my members will be forced to make drastic changes to their companies that, at best, will negatively affect their ability to grow, and at worst, serve as one more body blow that leads to employee layoffs and possibly even business closure.

Thank you for your consideration of our members' concerns. I repeat our industry's mantra on this matter: "Don't Change Our Change!"

Sincerely,

Jack Kelleher
Executive Vice President
Amusement & Music Operators Association

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5.9. Coin Laundry Association

Coin Laundry®
ASSOCIATION

June 18, 2014

Coin Stakeholders Response
Office of Coin Studies
United States Mint
801 9th St. NW, 2nd Floor
Washington, D.C. 20001

These comments are submitted for the record to the United States Mint, on behalf of the Coin Laundry Association (CLA) in response to the recent request, included in the Federal Register, for comments on potential alternative metal compositions for circulating coinage pursuant to the Coin Modernization, Oversight and Continuity Act of 2010 (Pub.L.111-302).

The Coin Laundry Association (CLA) supports the U.S. Mint's efforts to research ways to improve the cost-efficiency with which it manufactures coinage. As an industry made up of more than 20,000 small-business owners operating 30,000 self-service laundries throughout the United States, we applaud all efforts to save taxpayers' dollars. We believe that these efforts ought to be focused on the denominations whose costs to manufacture exceed their face values.

Transactions in our industry are conducted via the quarter more than 90% of the time. We understand that the quarter is efficient to manufacturer at a cost of less than 11 cents, according to the United States Mint. If the quarter were to be changed in a non-seamless manner, it may require a broad and expensive re-tooling of the approximately 27,000 laundries in the U.S. that use quarters.

These 27,000 laundries each feature an average of 58 washers and dryers per location – of course, some have many more machines. That math produces a conservative estimate of 1,566,000 coin mechanisms in our laundries today.

To replace and update these coin mechanisms with new ones designed to accommodate newly constituted quarters (along with the legacy quarter) would put an enormous financial burden on the shoulders of Mom and Pop laundry owners across the country. With parts costs combined with labor expenses, each coin mechanism would carry a replacement cost of at least $100 to $300 each – or a **total re-equipping cost of $156,000,000 to $470,000,000 for our businesses.** This conservative estimate does not include the millions in expenditures to retrofit coin changers, coin counters, soap venders – along with soda and snack machines. This estimate also doesn't account for the very large, multi-housing laundry industry, which provides laundry services in apartments and dormitories.

Facing re-equipping costs like these would force many laundries to close their doors. Others would be compelled to raise vend prices to offset the costs.

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www.coinlaundry.org
www.planetlaundry.com

Our customers are an important stakeholder as well. Our laundries provide a basic public health service to more than 7 million families each week. These families are often among the lowest income members of the community and can ill-afford increases to the costs of doing laundry. The typical laundromat customer comes from a household income of just $30,000 per year – just a notch above the poverty level.

As small-business owners, our members rely on gaining any efficiency possible in operating the business. With that goal in mind, many of our members weigh their weekly collections as an efficient way to process the coins collected. If in the future two quarters with two different weights were to co-circulate, this very important operational efficiency would be lost, costing business owners valuable time and effort. In fact, a new requirement to sort quarters would likely result in the need to invest in additional coin-sorting equipment.

When considering the potential for hundreds of millions of dollars of costs to our industry – and with many of our members still struggling through a sluggish economic recovery, **The Coin Laundry Association requests that the U.S. quarter remain unchanged.**

The CLA is also proud to be part of the Don't Change Our Change coalition and the collective effort to educate the United States Mint and legislators. Any change to U.S. coinage that would require a wholesale re-equipping of coin mechanisms would exact a devastating cost to these small businesses.

On behalf of the retail, self-service laundry industry, I would like to thank the United States Mint and its Office of Coin Studies for including us in this important process. You have been excellent partners in educating self-service laundry owners about this complex issue. We stand ready to provide whatever additional information or input might be helpful to you in this endeavor.

Sincerely,

Brian R. Wallace, President/CEO
Coin Laundry Association
1S660 Midwest Road, Suite 205
Oakbrook Terrace, IL 60181
www.coinlaundry.org

5.10. Canadian Automatic Merchandising Association

To whom it may concern,

As part of our long-term relationship with NAMA, the Canadian Automatic Merchandising Association will fully support NAMA's position on potential coinage changes in the US.

As the Canadian public has experienced several currency (Coin and Bank Note) changes over the past 18 years, there has been 3 distinct coinage change events, in 1996, 1999, and 2012. In all of these events, the financial burden was more impactful on businesses that provide unattended commerce. The traditional attended retail environments felt little to no financial effect on a change in weight, Electromagnetic Signature, diameter, or thickness of coins.

The Canadian unattended business segment has bore all the cost of these changes, with some companies not being able to manage the conversion costs, resulting in bankruptcy or the sale of their business. This was reported during or shortly after mandated coinage changes in the 1990's. The primary reason was associated to antiquated or less sophisticated coin recognition technology, which dictated the replacement to more modern electronic devices or the need to send those less sophisticated devices in for servicing, leaving machines out of order for several weeks, at a time. This had a significant impact on revenue earned by the business owner which limited cash flow and drove down the flexibility of their business to grow for a few years. As it related to the 1996 change from the $2 bank note to the $2 coin, many business owners leveraged the physical transition from paper to alloy as a justification to increase selling price to the consumer. This allowed the operator to reclaim some of the loss associated from the conversion of the equipment and in eyes of the public was acceptable. However, most operators believed, this strategy could not be done with a like-for-like transition, such as, a change in alloys used. The Canadian consumer views a 25 cent **coin** as a 25 cent **coin** which should be accepted on a vending machine easily. The consumer does not look at the mintage year on a coin before putting it into a vending machine to see if it will work or gain understanding why it did not accept. In fact, some less informed or less interested Canadian operators, took years to upgrade their systems to accept the 1999 issued multiply plated steel coins that were circulation. They waited until the circulation based tilted in favor of the MPPS coins before converting. I consider this a less than optimal business decision to deal with the change but it illustrates the long term financial impact this can have. Conversions that spread over years, result is a reduced confidence in the consumer that the vending machine is a reliable source to purchase product from and becomes a greater industry problem.

The largest challenge with making a coin change on the Canadian unattended industries was the cost to move from antiquated coin accepting devices to new modern devices which have in-field / in-machine upgrading options. It is not just the replacement costs, but the labor to execute an upgrade program and the potential costs to modernize the machines themselves to accept the newer coin accepting devices. Once new technology is in place, the upgrade process is easier for the next time a coin change is needed, but still has significant labor cost to execute. This is an important point to understand, as it relates to selecting secure materials or a unique blend of materials to produce a new iteration of a coin. If the fraud potential increases because less secure materials are used, the likelihood of reprogramming increases as well. Although frauds tend to be a local to regional problem (not nationwide), the costs would be similar to address a fraud as it would be for a new coin on business owner.

Regardless of when a coin change occurs, continued open dialogue is necessary with all stakeholders throughout the process and roll out programs require significant communication plans to minimize economic impact to the industry business owners and maximize public awareness.

Ed Kozma
President
Canadian Automatic Merchandising Association
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ekozma@vending-cama.com
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5.11. International Association of Amusement Parks and Attractions

International Association of Amusement Parks and Attractions

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Alexandria, VA 22314 USA

Tel: +1 703/836-4800
Fax: +1 703/836-1192
Email: IAAPA@IAAPA.org
www.IAAPA.org

Office of Coin Studies
United States Mint
801 9th Street N.W.
Washington, DC 20220
Via email: Coin.StakeholdersResponse@usmint.treas.gov

June 20, 2014

Re: Notice with Request for Comment on Effects of Changing the Metal Composition of Circulating United States Coinage

The International Association of Amusement Parks and Attractions (IAAPA) represents more than 4,500 facility, supplier, and individual members from more than 90 countries. In the United States, IAAPA has members in all 50 states. Member facilities include amusement and theme parks, water parks, attractions, family entertainment centers, arcades, zoos, aquariums, museums, science centers, and resorts. The attractions industry in the United States directly provides 1.275 million jobs, and has a total direct economic impact of $91.4 billion.

IAAPA is writing in response to the recent Notice with Request for Comments on the effects of changing qualities such as weight, color and electromagnetic signature of our circulating coinage. IAAPA's members appreciate the desire to reduce the costs associated with manufacturing coins, however changing the make-up or size of coins would have negative financial ramifications for their businesses.

Costs to Update Equipment

Any change to coinage will result in increased costs to update equipment, and address issues with co-circulation of the old and new currencies. These costs may affect the attractions industry's ability to grow and create jobs. It is estimated changes in the metallic content or size of coins will cost coin operated machine operators between $100 and $500 per machine in upgrade costs to accept new coins. There are approximately ten million coin-operated machines in the United States, which leads to an estimated burden of close to $5 billion. There is no return on investment for these equipment upgrades.

Challenge with co-circulation

Co-circulation, and the uncertainty associated with the length of period established by the government, poses a significant technological and financial burden on the industry. To date, no mechanism exists that can accept and process coins with different electronic signatures. Until this technology is created, operators and consumers will experience faulty machines. It is not out of the realm of expectations to assume that should

Regional Offices:

IAAPA Asia Pacific
Hong Kong SAR, China

IAAPA Europe
Brussels, Belgium

IAAPA Latin America
México City, México

breakdowns frequently occur, machines will be pulled from service, hurting business owners and limiting consumer choice.

IAAPA appreciates the opportunity to discuss the challenges the industry will face if the Mint alters the qualities of coinage. Should you have additional questions, please do not hesitate to contact me at rdavis@IAAPA.org or 703.836.4800.

Sincerely,

Randy Davis

Randy Davis
SVP, Safety & Advocacy

5.12. International Parking Institute

INTERNATIONAL PARKING INSTITUTE

Advancing the parking profession

Comments from the International Parking Institute to the United States Mint's Federal Register Notice of April 10, 2014

The International Parking Institute (IPI), the world's largest organization representing the parking industry, is providing the following comments regarding the April 10, 2014 Notice regarding factors identified as a result of the Bureau's research and development efforts on alternative metals for circulating United States coinage.

Background

For more than 50 years, IPI has provided leadership, information, and training to advance the parking profession. The association's membership is comprised of organizations managing, owning, constructing and operating parking programs here in the United States and in 46 countries across the globe. IPI members include cities, academic institutions, commercial operators, port authorities, hospitals and healthcare facilities, airports, corporate complexes, transit and transportation agencies, retail, entertainment and sports centers, architects, engineers, urban planners, as well as all of the companies manufacturing or providing equipment, software or services to the parking industry.

The average automobile stays parked approximately 96 percent of its life. In the United States, parking is considered a service to customers traveling to work, shop, business, social, recreational, entertainment, education, medical and many other purposes. Parking is provided by a broad spectrum of public and private companies and in many cases, fees are collected to pay for this service.

Parking inventories are typically categorized by space type, including on-street, surface lot, multi-story garage/structure, and private. It is estimated that the United States has more than 220 million commercial parking spaces. IPI estimates that, at a minimum, half this number is provided on a for-pay basis, with this percentage anticipated to increase every year.

The U.S. parking industry generates over $30 billion in annual revenues.

Metered Parking

Since the development of the parking meter in 1935, both public and private entities have been able to manage on- and off-street parking. The total number of parking meter spaces is estimated to be approximately two million metered spaces.

The construction of the parking meter has evolved since 1935. The outside shell has gone from steel to cast iron or zinc alloy offering greater durability and a reduction in vandalism. The mechanisms inside the meter have evolved from spears and gears to electronic components.

1330 Braddock Place
Suite 350
Alexandria, VA 22314
P: 571.699.3011
F: 703.566.2267
parking.org

Parking meters have been calibrated to accept various U.S. coins (primarily quarters). Precise calibration of the meter's mechanism can detect and avoid fraudulent, counterfeit coins (slugs). Therefore, a coin's material, construction, dimension, thickness and electrical/magnetic properties play an important role in whether the coin will be accepted for payment.

Technology Improvements

Mechanical to Digital

Over the past decade, parking control systems have transitioned from mechanical, electro-mechanical, and electronic-only to computer-based systems, with access and revenue management software offering central reporting and control of a facility. This offers the ability to provide enhanced functionality and handle scenarios such as credit card in/credit card out, debit cards, etc., in real time. New generations of IP-based addressable "smart" equipment are able to report their operational status and be controlled via Ethernet networks and existing internet infrastructure. These technologies also allow the support and monitoring of multiple facilities across town, around the country, or across the globe. Wireless communications are also playing an ever-increasing role.

Cash to eMoney

eMoney (electronic payment) is a non-cash payment that is exchanged electronically. It involves the use of a computer network, the internet and, in some cases, stored value systems. This takes advantage of varied and new technologies, with use and acceptance starting in Europe.

eMoney does have costs associated with processing fees, but generally these are less than cash handling. It is also a more secure payment method with greatly-reduced possibilities for theft as compared with a cash-based system.

The most widely-used media for electronic payment is the credit/debit card. These can be accepted in most locations, even as "payment on the go" with the addition of card readers that attach directly to many smartphones and use the cellular network for communication to a clearinghouse. This combination allows customers to pay for any good or service any time, anywhere.

Mobile commerce is a growing area of technology. A smartphone device can be used to make payments for all kinds of goods and services. Most commonly, the device is used as a credential which is linked to a credit card or bank account from which funds are drawn and transferred to the merchant (parking operation). Sometimes the payment application is generic and can be used for any purpose; in other cases, the payment is tied to a transaction in parking (such as pay-by-cell). Pay-by-cell merges the phone with contactless credit card and gives the customer the ability to communicate with devices locally.

On- and Off-Street Parking

On-street parking is also becoming high-tech. Single space meters can take credit cards, making payment easier. The multi-space meter reduces both the hardware and the revenue collection time and personnel needed. A pay-and-display multi-space meter typically manages 15-20 spaces and is great for short-term studies of parking use. Pay-by-cell (PBC) is now available in more than 250 locations in North America.

Effect of Using Alternative Metals in U.S. Coins

Potential changes to current coin construction, content, weight, dimension or EMS will affect how effectively the parking meter operates and, ultimately, the customer's experiences parking their car. As currently stated, change to the coin [U.S. Mint calculates that coins can stay in circulation for up to 30 years] will require that parking meters be retrofitted to accept current and proposed new coins for the foreseeable future.

Not knowing the actual changes being considered to U.S. coins and after discussions with vendors and suppliers of parking equipment, it is estimated that retrofitting parking meters could cost $200-$300 per machine (excluding labor costs). These costs, in addition to the labor required, will be directly absorbed by the meters' owners (cities/municipalities). Retrofitting or replacing meters to recognize new coins could cost the meters' owners more than $400,000,000.

Transition & Implementation Period

Due to the significant number of parking meters that would require retrofitting to recognize both new and old coins, the parking industry requests three to five years to implement and upgrade our industry's equipment should a change be made to U.S. coins. Because, in many cases, revenue generated by parking management supports many other government functions (police, fire, emergency rescue, road maintenance), this transition period would also benefit the cities and local authorities to allocate their costs and adjust their budgets to minimize any disruption to service over a longer period of time.

The International Parking Institute applauds the U.S. Mint's efforts to provide open communications and dialogue among all key stakeholders during this notice period.

Thank you for considering the International Parking Institute's comments.

Sincerely,

Shawn Conrad

Shawn D. Conrad, CAE
Executive Director

5.13. Multi-housing Laundry Association

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June 12, 2014

By Email, Original by Mail

Coin Stakeholder Response
Office of Coin Studies
United States Mint
801 9th Street, N.W.
Washington, D.C. 20220

Gentlepersons:

We serve as counsel to the Multi-housing Laundry Association (MLA), and submit these comments to the United States Mint on MLA's behalf in response to the April 10, 2014 Federal Register notice seeking comments of coin industry stakeholders on the impacts of changing the metal composition of United States coinage. We understand from the Federal Register notice that the Mint is especially interested in impacts of changing the weight and electromagnetic signature of existing coinage.

MLA is the trade association that represents the laundry service companies that operate laundry machines in central laundry rooms in multi-housing dwellings – such as apartment buildings, college dormitories and military bases. MLA's member companies and other companies in this industry purchase and install washers and dryers in central laundry rooms throughout the United States. Companies in this industry maintain, repair, service and replace these machines and regularly collect the coins paid into the coin boxes. There are approximately

137203-1

1.8 million machines nationwide in central laundry rooms that receive cash payments, almost all in quarters.

If the quarter coin is altered in weight or electromagnetic signature, MLA believes that coin acceptance devices in the 1.8 million machines in central laundry rooms that now receive coin payments would need to be replaced. MLA estimates the one-time cost of paying for new devices would be about $100 per machine, and that the one-time labor cost of installing them would be about $100 per device – totaling $360 million in one-time costs for the entire industry.

This amount could be increased if the Mint were to change the weight or electromagnetic signature of the quarter coin while also leaving existing quarter coins in circulation. (MLA understands from the stakeholders meeting held at the Mint on March 13, 2014 that an existing quarter coin currently remains in circulation for an average of thirty years). In that event, coin acceptance devices would need to be adapted to accommodate both types of quarters (differing in weight or magnetic characteristics) and the expense to the industry MLA represents would be even greater.

By contrast, MLA understands that the Alternative Metals Study commissioned by the U.S. Mint concluded that altering the quarter coin would save the Mint in the range of only $10 million a year (see Alternative Metals Study, pp. 166-169 and Table 3-6). Given the very substantial disparity between the savings to the Mint and the costs that any change in the weight or electromagnetic signature of the quarter coin would impose on MLA's members and other companies in this single industry alone, MLA strongly opposes any such change.

Please do not hesitate to contact me if you have any questions of MLA or wish to discuss this matter further.

Kind personal regards.

Sincerely,

Reid Peyton Chambers

cc (by email):

Robert Doyle
Penney DePas
Harvey Gitlin
Mike Marsden
Len Samela
Rodd Schaffer
Allen Stanwix

137203-1

5.14. National Automatic Merchandising Association

Serving the Vending and Refreshment Services Industry

June 17, 2014

Coin Stakeholders Response
Office of Coin Studies
United States Mint
801 9th Street NW.
Washington, DC 20220

RE: Coin Modernization, Oversight, and Continuity Act of 2010 Federal Register Request for Comments

Dear Sir or Madame,

This letter is in response to your recent request, included in the Federal Register, for comments on potential alternative metal compositions for circulating coinage pursuant to the Coin Modernization, Oversight, and Continuity Act of 2010 (CMOCA) (Pub. L. 111-302). The CMOCA authorized the Secretary of the Treasury to conduct research and development (R&D) on alternative metallic materials for all circulating coins with the goal of reducing production costs.

Founded in 1936, NAMA is the association representing the $42 billion U.S. vending and refreshment services industry. With 1800 member companies – including many of the world's most recognized brands – NAMA provides advocacy, education and research to its membership.

Each day, millions of American consumers choose vending to purchase a broad range of products with the use of U.S. coin currency. Consumers are able to make their purchases with confidence, as the industry has a very high trouble-free vend rate due to consistencies in coin composition and currency-reading technology.

Paper and metallic currency continue to be the main form of payment used for buying food and beverages from vending machines representing over 90% of industry transactions. This fact further emphasizes the impact that recommended changes to coins will have on the vending channel and why they must be carefully researched and considered before being presented to Congress.

The vending and refreshment services industry understands and appreciates the U.S. Mint's concern with cost containment for the production and distribution of circulating coinage, especially as it relates to the penny and nickel denominations. However the Mint is reminded that its overall coin production and distribution system creates a net profit and that its own data has shown that costs of metals fluctuate frequently within the commodity markets.[40]

When passed, NAMA supported the Coin Modernization, Oversight, and Continuity Act (CMOCA) because it was believed that the bill language protected vending operators and the coin acceptance community from potentially billions of dollars of unnecessary new coin validation costs. However, as a result of the Mint's 2012 Biennial Report to the Congress on the Current Status of Coin Production Costs and Analysis of Alternative Content and recent developments, NAMA is concerned it will be difficult for the Mint to recommend a metallic content that significantly reduces the costs to produce circulating coins while balancing the bill's requirement that the Mint must consider factors relevant to the ease of use and ability to co-circulate of new coinage materials, including the effect on vending machines and commercial coin processing equipment and making certain, to the greatest extent practicable, that any new coins work without interruption in existing coin acceptance equipment without modification.[41]

In addition to the costs concerns, there are other issues that should be considered during the Mint's research and development efforts.

Impact on Small Business

There are an estimated 7 million food, beverage, and product vending machines in the U.S. and the costs to accommodate changes in these machines for new coins would range from $100-$500 per machine. As highlighted in the Mint's 2012 Biennial Report to Congress, changes in the metallic content of coins could create a financial burden on the vending industry, which is comprised of over 90% small businesses.[42]

> "The vending machine industry estimates that the best and worst case cost scenarios to modify the vending machines in the United States to accept coins of the same size and similar weight as existing coinage but with a different electro-magnetic signature would be between $700 million and $3.5 billion, assuming a one-time, standalone, universal upgrade. CTC's analysis includes consideration of the refresh and maintenance cycles of existing vending machines and places the conversion estimate at between $380 to $630 million."

NAMA is opposed to any changes in coins that would place a financial burden on the vending industry or cause an interruption of service to existing coin acceptance equipment without modification.

Changes to Acceptance Rates of Coins

Metallic content updates could change the acceptance rates of coins causing customer frustration resulting in lower sales and decreased revenue to all levels of government. A May 2012 Wall Street Journal article cites examples of this phenomenon following the release of Canada's new loonies and toonies—its $1 and $2 coins.

> "Canada's just-released new loonies and toonies—its $1 and $2 coins—are slightly lighter than the old ones. And that's causing a lot of headaches (and expense) for vending-machine operators and city governments who have to recalibrate their coin slots and local parking meters. Ottawa may be saving money with the new loonies and toonies, but the Toronto Parking Authority says it will cost more than C$1 million to recalibrate the city's 3,000 parking meters, about C$345 per machine. And Calgary says it's budgeted over C$30,000 to convert its meters. Vending-machine operators, not surprisingly, are not pleased, either. The Canada Gazette, the government's official newsletter, estimated earlier this year that it'll cost the vending industry C$40 million to

> recalibrate what it calls "coin-acceptance equipment." Canadian media are already carrying reports of vending-machine abuse as the new coins keep returning to the slot at the bottom of machines. One Laundromat owner in Toronto says she's having to spend C$5000 just to recalibrate the machines in her place of business."[43]

Changes in metallic content may force coin validator manufacturers to increase the verification security level of coins thereby restricting and lowering the acceptance rate of the genuine coins to protect against counterfeiting or misreading of the coins. This could lead to customer dissatisfaction when apparently good coins are rejected and vending sales are negatively affected.

Reductions in sales could also create a negative impact on jobs, and less corporate taxes being collected from the vending channel at every level of government from local to federal. This impact on government receipts should be included in any cost-benefit analysis performed.

Impact on Vending Must be Considered

We remind the Mint that it must consider the impact on the vending industry in any recommendation that it presents to Congress. We applaud the Mint's excellent stakeholder outreach effort and hope that it will provide the needed information and data to meet the requirements of the CMOCA bill language concerning the impact on the vending industry on any recommendation(s). However, we remain concerned that technology and metallic content costs and other factors may make this a difficult requirement for the Mint to balance the impact to the vending channel and meet the cost savings intent of this directive.

The vending industry also has concerns with the impact that co-circulation of coins would have on the industry and its consumers. This issue was raised related to changes made in Canada, by Andrew Mills the Director of Circulating Coin for The Royal Mint, during a recent hearing before the U.S. House of Representatives Subcommittee on Monetary Policy and Trade.

> "[T]he smaller 50p was introduced in September 1997 ready for coin demand leading up to Christmas that year. The larger 50p was removed from circulation in 6 months to assist the vending industry ***as co-circulation of different specification coins of the same denomination can lead to lower reliability of their machines***."[44]

As noted by Mr. Mills, co-circulation could lead to reliability issues. Furthermore, it would also create the need to expand the size of the coin acceptance device. The current configuration of vending machines, that accept U.S. coins, does not allow space for extra tubes to be added in its traditional location in vending machines. New vending machines and apparatus would have to be developed to create space for the extra tubes needed to provide acceptance and change functionality within the coin device. This would cripple the industry and NAMA strongly recommends that any recommendations for changes in coinage include that there be no co-circulation of different specification coins of the same denomination.

Transition and Compliance Period

If changes can be made that don't negatively impact the vending industry, NAMA recommends that a long notice, transition and compliance period must be part of any recommendation that is presented to Congress. Changes without a limit on co-circulation may require that multiple versions of coins be accepted for many years. Circulation time periods of coins and the capability of coin acceptance devices

and vending machines that accept multiple co-circulating coins, should be considered when assessing the transition and compliance period. The impact of co-circulation of coins should be fully vetted with coin acceptance device manufacturers before any recommendation as to transition and compliance period is made. The Mint's 2012 Biennial Report to Congress emphasizes that the industry should be provided with significant advance notice of two to three years.[45]

Reduction in Federal Government Revenue

Changes in coins that create an expense for vending operators will lower revenues to the U.S. Treasury and add costs to the government. Business expenses for upgrading equipment have no return on investment (ROI). Therefore, those expenses reduce profit, lowering the amount of profit for the corporation and the corporate income taxes that the federal government will receive from the industry. For example, if upgrades to coin acceptance equipment have a $1 billion cost to business, the U.S. Treasury's tax revenue will decrease by the amount of corporate tax it would collect on the $1 billion in revenue. This cost to the government should be considered in any cost-benefit analysis performed.

Costs to Mint and Federal Government

Any updates to coins will have a tremendous financial impact on the Mint and federal government agencies through the need to educate the public on the new coins. If coins are changed, massive amounts of public education and awareness campaigns would have to be created and performed. This tremendous effort will produce a financial commitment from the U.S. Mint and federal government agencies that must be considered in any financial analysis portion of a recommendation that purports to create savings.

Also, changes in the metallic contents of coins may have impacts on the production cost by impacting the die life of the equipment used to forge and create coins. Different metals could increase the frequency of die changes, which can be disruptive to the production process and create increased manufacturing costs for coins. This impact should be assessed as well.

Federal Register Notice

The Federal Register Notice presents specific statements for comments. Below are our responses to these statements:

a. *A change to the diameter or thickness of U.S. coins would have a significant negative impact.*

Comment: Size and shape of coins is very important to the vending industry and its coin acceptance devices. The vending industry would oppose any change to the diameter or thickness of coins, as that would have the largest potential financial impact on the industry and cause interruption in existing coin acceptance equipment due to the extensive modification or replacement needed to accept coins with a different diameter or thickness.

b. *The quarter-dollar coin is the workhorse of circulating coins. Across stakeholders, any change to the quarter-dollar coin would bring about the most costly conversion to a new alternative metal quarter-dollar coin.*

Comment: The quarter-dollar coin is very important to the vending industry. Any substantial change to the quarter-dollar coin would have a significant financial impact on the vending industry. The Mint should closely survey vending and coin acceptance equipment to determine its ability to accept and make change for customers, with co-circulating quarter-dollar coins of differing specifications. As stated earlier, the current configuration of coin acceptors in vending

machines does not allow physical space for expansion of the size of the coin acceptance device, a need that would have to be met with the co-circulation of quarter-dollar coins; especially due to their being the largest sized circulating coin.

c. *Aluminum alloy coins do not perform well at high speeds and high pressures of coin sorting and handling equipment.*

Comment: Aluminum alloy coins present significant problems for coin changers in the vending industry. The reduced weight of an aluminum coin, particularly smaller ones like dimes, could present difficulty with the coin properly traveling through the coin chute and the accepter module for analyzing of value and authentication.

Furthermore, when faced with a similar rise in commodity prices on the world markets in the early 1970's the Mint tested alternative metals, including aluminum and bronze-clad steel. A composition of 96% aluminum with trace elements of stability was chosen for the new one-cent pieces. The proposal for this new one-cent piece was rejected in Congress mainly because of issues raised by industries who felt the coins would cause mechanical problems.[46] The Mint is urged to review their Congressional recommendation and research from the 1974 Aluminum Cent proposal and refrain from moving forward with another attempt at aluminum alloy coins.

d. *A generous amount of communication and education is both needed and expected before implementing the use of alternative materials for the nation's circulating coins.*

Comment: For any changes in the metallic content of coins to be successful, the American public, international community and impacted industry must be fully educated on the new coins before they are released into circulation. This education will take time and financial resources. This time should be taken into account when determining transition periods and the costs should be considered in any cost/benefit analysis.

e. *If new coin handling equipment or software is needed, manufacturers of coin handling equipment need six to 12 months with production sample coins before they can begin shipping the new updated equipment to end users.*

Comment: A six to twelve month lead time for equipment or software manufacturers to begin shipping the new updated equipment to end users is acceptable as it relates to the limited issue of manufacturers lead time needed for shipping. However, the time needed for vending operators to update each machine, and to update the coin acceptance units, is much longer than the six to twelve months needed by the manufacturer to deploy the new equipment or software.

f. *The transition period for end users to implement an alternative material coin should be at least 18 months from the date the alternative material coin is announced and before it is put into circulation.*

Comment: Eighteen months is not nearly enough time for the transition period needed for end users to implement an alternative material coin. This is primarily due to the requirement of vending operators, and their limited staff of service technicians, to visit each machine to manually update them with the new equipment or software to accept the new coins. It is estimated that technicians could update 10-15 machines per day if the machines are widely dispersed geographically. Therefore if an operator owns or services 1000 machines, it could take 100 work days or roughly five to six months to update those machines. This estimate also assumes that the

technicians are not responsible for answering other maintenance and repair calls at the same time, which is not a fair assumption in the industry.

Many vending operators classified as small businesses by the Small Business Administration, own between 1000 and 3000 machines. It could take a small business with 3000 machines nearly eighteen months to update their machines. There are many operators in the industry that own more than 300 vending machines. Therefore to ensure full adoption, a more reasonable time period for the transition period for end users should be a minimum of 30 months from the date the alternative material coin is announced and before it is put into circulation.

g. The total time period needed for a smooth transition is 18 to 30 months.

Comment: The Mint's 2012 Biennial Report to Congress emphasizes that the industry should be provided with significant advance notice of two to three years. Therefore, we agree with the Mint that a transition period of 18 months is not acceptable for the industry and consumers and that it is closer to three years.

Assuming there is no co-circulation of different specification coins of the same denomination, NAMA recommends the time period needed for a smooth transition be set at between four and five years. This provides the six months lead time for manufacturers to disperse the new equipment and technology to operators, three years for vending operators to update equipment, and one to one and a half years for public education on the new coins. We are concerned that the industry and consumers will suffer greatly if the American public is not properly educated on the new coins before they are in circulation.

Thank you for allowing NAMA to comment on behalf of the vending and refreshment services industry. Please do not hesitate to contact me if you should have further questions regarding these comments or the impact of the potential change of coins on the vending industry.

Sincerely,

Carla Balakgie, FASAE, CAE
President & CEO

The National Automatic Merchandising Association • www.vending.org
Headquarters: 20 N. Wacker Drive, Suite 3500 • Chicago, IL 60606-3102 • Voice: 312/ 346-0370 • Fax: 312/ 704-4140
Eastern Office: 1600 Wilson Blvd., Ste. 650 • Arlington, VA 22209 • Voice: 571/346-1900 • Fax: 703/836-8262
Southern Office: P.O. Box 4110 • Alpharetta, GA 30023 • Mary Lou Monaghan: Voice: 678/ 232-7941 or Sheree Edwards: Voice: 313/673-7875
Western Office: 80 South Lake Avenue, Suite 538 • Pasadena, CA 91101 • Voice: 626/229-0900 • Fax: 626/229-0777

5.15. National Bulk Vending Association

NBVA Stakeholder Outline – Second Revision

"First and foremost, the Mint is all about facilitating commerce."
– Mr. Richard Peterson, Deputy Director of the US Mint

The National Bulk Vendors Association has represented the bulk vending industry since 1950. Among our purposes, we act to preserve and protect the bulk vending industry from detrimental legislation. As an industry, we oppose changing the composition of the US Quarter.

The outline below from the US Mint's 2011 Annual Report shows the manufacturing costs of U.S. coins. The evidence below does not support changing the composition of the Quarter. The Penny and the Nickel, perhaps, but not the Quarter:

$1 Coin	Quarter	Dime	Nickel	Penny
18.03 cents	11.14 cents	5.65 cents	11.18 cents	2.41 cents

(United States Mint, 2011 Annual Report, pg. 11)

Changing the Quarter's weight, magnetic signature, or size would have immediate and devastating impacts on the bulk vending industry. Bulk vending machines (Examples pictured below) have mechanical mechanisms, or "mechs" in industry parlance, that collect coinage and dispense product. The mechs are manufactured for the specific size, shape and material content of specific coinage. There are millions of coin mechs being used today from car washes to bubble gum machines.

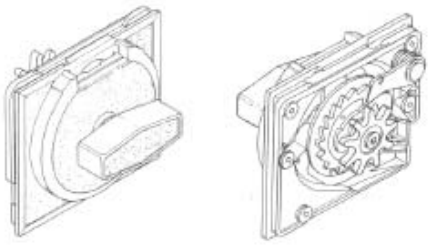
The Quarter is the workhorse of the bulk vending industry. Nearly all bulk vending machines in the United States rely on the Quarter as their sole currency. Changing the composition of the Quarter would make all these machines obsolete as their current coin mechanisms could not accommodate a new coin. Changing the Quarter would destroy the livelihood of many small business owners. This change in the Quarter would also affect the larger supply companies that sell products and machines to these smaller businesses. In short – the decision to change the Quarter would cost jobs, which goes directly against Mr. Peterson's statement above.

The National Bulk Vendors Association supports you in your goals to save the U.S. taxpayer money. One of the ways this could be accomplished is to support the dollar coin. These coins are already made, but are waiting for legislators to release them from political purgatory. The Government Accountability Office estimated that switching to a dollar coin would save the American people $5.5 billion[1]. This is real change.

In summation, the NBVA pleads that you do not change the composition of the US Quarter coin. This change would cost $41,238,000; this change will cost jobs and destroy an iconic American industry.

Bulk Vending Machine

Bulk Vending Mechanism or "Mech"



We respectfully thank you for your consideration,

The National Bulk Vendors Association

1. http://www.gao.gov/new.items/d11281.pdf

5.16. National Council of State Agencies for the Blind

NCSAB

National Council of State Agencies for the Blind, Inc.

4600 Valley Road, Suite 100
Lincoln, NE 68510-4844
Telephone: 402-471-8100 or 402-471-8101
Fax: 402-471-3009

Robert Doyle, President — Sue Schaffer, President-Elect
Pearl Van Zandt, Treasurer — Katy Morris, Secretary

June 9, 2014

Beverly Ortega Babers, Chief Administrative Officer
Office of Coin Studies, United States Mint
801 9th Street NW
Washington, DC 20220

Dear Ms. Babers:

Thank you for the opportunity to offer comments on the impacts of altering the metal composition of circulating United States coinage. I am writing on behalf of the National Council of State Agencies for the Blind (NCSAB), the national body representing the State Licensing Agencies that administer the Randolph-Sheppard Act in the various states, to provide cost estimates and relay concerns over possible changes to U.S. coin composition.

The Randolph-Sheppard Act provides entrepreneurial opportunities to blind vendors in the food service industry. Nationwide, there are 2,545 blind vendors participating in the Randolph-Sheppard program. These vendors operate 3,031 facilities on federal and state property. Most of the vending facilities in the Randolph-Sheppard program are small "mom and pop" operations, with one or two full-time employees in addition to the blind entrepreneur. In 2012, the last year for which figures are available, vendors in the Randolph-Sheppard program earned, on average, about $56,000 per year from their vending facilities.

1. Vendors would benefit from a longer transition period for implementing costly adaptations. Our member agencies agreed that a shorter conversion period would increase the cost of a nationwide conversion. Manufacturers, technicians, and operators need a 30-month transition period to analyze the new coins, develop new equipment for vending machines, and upgrade all machines before the new coins enter circulation.

2. The vending machine industry anticipates a much steeper nationwide conversion cost than the U.S. Mint estimates. The Mint estimates that a one-time, standalone conversion of the nation's vending machines could cost between $380 and $630 million. The vending machine industry, however, estimates a nationwide conversion cost ranging from $700 million to $3.5 billion.

3. Technological issues present unpredictable variables that make potential costs difficult to calculate. The U.S. Mint has not stated whether the new coinage will differ only in electromagnetic signature, or also in weight, size, and color. The specifications for the new coins will determine whether the state's vending machines will require a recalibration, or all new coin-accepting equipment. The vending machine industry is also uncertain that a modification exists that will allow vending machines to accept current and new coins simultaneously. This means the conversion cost estimate must reflect both the cost of a nationwide recalibration, and the cost of new equipment to accurately reflect all contingencies.

4. Direct conversion costs vary by state. A small, rural state like Kansas, for example, can expect statewide conversion costs between $75,000 and $150,000 for the nearly 300 vending machines in its Randolph-Sheppard program. A large state like California, however, has closer to 3,000 vending machines operated by blind entrepreneurs. A state of that size can anticipate a statewide conversion costing anywhere from $286,000 to $1,430,000.

5. Indirect costs could double the overall costs of adapting machines to the new coinage. If new coins are already in circulation during the conversion period, the unconverted machines will be vulnerable to jams. These jams will require service calls, and the machines will lose revenue while they are out of order and awaiting maintenance. The Kansas BEP, for instance, estimates that these indirect costs could double the direct cost of the conversion and potentially cripple the state's Randolph-Sheppard program.

6. Changes to U.S. coinage could adversely impact the ability of the blind or visually impaired to distinguish coins by touch. Certainly, the Mint is aware of and is working to comply with the October 2008 ruling by the U.S. District Court for the District of Columbia that the Department of the Treasury must provide meaningful access to U.S. currency for the blind or visually impaired. Changes in the metal composition and design of coins have important implications for the visually impaired community. The national organizations representing the blind stand ready and willing to work with the Mint to ensure that changes do not adversely affect persons who are blind or visually impaired.

Thank you, again, for the opportunity to offer feedback on potential changes to the metal composition of U.S. coinage. We look forward to working with you to preserve the livelihoods of the blind entrepreneurs who operate vending businesses under the Randolph-Sheppard Act.

Sincerely,
Catriona Macdonald
Policy Advisor
National Council of State Agencies for the Blind

5.17. National Parking Association

1112 16th Street NW, Suite 840
Washington, DC 20036

T 800.647.PARK
P 202.296.4336
F 202.296.3102
www.npapark.org

NATIONAL PARKING ASSOCIATION

June 24, 2014

Coin Stakeholders Response
Office of Coin Studies, United States Mint
801 9th Street NW, Washington, DC 20220
Coin.StakeholdersResponse@usmint.treas.gov

To Whom It May Concern:

We appreciate the U.S. Mint's willingness to gather additional feedback on the business impact of changes to coin production. We understand that coin production has a cost and that periodically the U.S. Mint, U.S. Treasury and the U.S. Congress review monetary metals. The National Parking Association (NPA) represents more than 2,800 members and 800 member companies that own, manage, supply and service parking facilities across the United States and worldwide. There are approximately 143,000 employees in this industry in Canada and the United States.

We recognize the importance of evaluating alternate metals for the efficient production of coins, and appreciate the open comment period, which allows us to highlight how the good intent of rulemaking can have detrimental impacts on business operations. NPA and its members have significant concerns that the potential changes will require excessive conversion costs, pressure already tight public sector budgets and ultimately resulting in job loss, as well as the closing of small businesses.

We see the issues as:

1. Business burden to acquire capital to meet changes in accepting payments due to any changes in monetary metals.
2. Opportunity cost of capital that could be deployed for compliance with any changes required in equipment vs. investment in growth or service improvements.
3. Cost pressures that may cause a reduction in employment.
4. Process and transition issues, including timing.

The parking industry would be particularly disadvantaged by the changes because the majority of commercial operators are small to medium-sized, privately held firms, many of which are principally cash businesses. These companies would be faced with the costly decision to automate operations, or even close their doors.

For larger operations, both public and private the cost of new equipment, training, software and changes to business systems across their operations would be a financial and operational burden. This burden could accelerate automation and reduce employment.

For industry suppliers, the cost to redesign equipment, retool machinery, and produce new coin acceptors, produce new software and to convert facilities—would create significant upfront costs and opportunity costs to address any changes made to monetary metals.

The costs of new equipment design, conversion, machinery and production of equipment, training and software would be tens of millions of dollars within the supplier sector. The cost for parking operators

public and private would range from several hundred thousand to tens of millions of dollars depending upon size of operations. This could accelerate automation and reduce employment rapidly. An unintended consequence could be an increase in parking costs for consumers, as a result of increased operating overhead costs.

NPA gathered member input and surveyed its members and found the following:

- Industry suppliers would require 3-5 years to recapitalize operations, develop and roll out new equipment.
- At a minimum, it would take parking operators public and private five years to plan, budget and transition monetary metals—including securing capital, training staff and upgrading equipment.
- To offset the cost of adopting changes in monetary metals, 50 percent of respondents reported that they would reduce staff and 55 percent would raise prices by up to 25 percent.
- 100 percent of respondents accept quarters.
- 91 percent of respondents accept nickels and dimes; 87 percent accept dollar coins; and 52 percent accept half dollars.

Given these findings, we would recommend that if any changes to monetary coins are made that the adoption period for compliance should be a minimum of five-seven years, with an extension for small businesses of up to 10 years.

Furthermore, we do not recommend making any changes to the quarter as this would affect the largest number of businesses negatively. If changes can be made to monetary metals that allow for continued acceptance in existing equipment, this would significantly reduce the burden of any changes in monetary metals.

Thank you for the opportunity to engage in an open dialogue on this issue.

Sincerely,

Christine Banning, MA, CAE
President, National Parking Association
Washington, D.C.

5.18. Additional Associations

5.18.1. AAMA

Coin Stakeholders Response
Office of Coin Studies
United States Mint
801 Ninth Street NW, 2nd Floor
Washington, DC 20001

Dear Mr. Cameron,

This letter is in response to your recent request, included in the Federal Register, for comments on potential alternative metal compositions for circulating coinage pursuant to the Coin Modernization, Oversight, and Continuity Act of 2010 (Pub. L. 111- 302).

I am the owner of a small business, committed to my employees and my community. To put it bluntly, if you change the metallic content of the quarter I will be forced to make drastic changes to my business that will negatively affect my ability to grow at best, and may cause me to lay off employees and at worst cause me to exit the business.

Changing the composition of coins will require expensive modifications to coin mechanisms by the vending industry. For example, if changes to the metallic content occur, this will require expensive reprogramming of most coin validators. Such reprogramming requires a technician to visit all vending machines and transfer new data to the coin validators. Further, if mechanical changes are made to the coins, such as changes in sizes or weights, then even more expensive changes to coin validators will be needed. Expensive redesigns to the coin validators in addition to reprogramming will be required.

Changes in the metallic content of coins will cost vending operators $100-$500 per machine in upgrade costs to accept new coins. It is estimated that there are approximately 1 million coin-operated amusement machines in the United States. This equals an estimated burden on the coin operated entertainment industry of close to one half a billion dollars. Furthermore, there is no return on investment for vending operators on equipment upgrades, adding to business financial outlays and leading to job losses in America's recovering economy.

Changes in metallic content would force coin validator manufacturers to increase the verification security level of coins thereby restricting and lowering the acceptance rate of the genuine coins to protect against counterfeiting or misreading of the coins. This could lead to customer dissatisfaction occurring by apparently good coins being rejected and vending sales will be negatively affected by this rejection.

I ask you to look at the Canadian experience. In a cost-savings effort, the new Canadian coins used multi-ply steel technology, which makes them cheaper to mint than their alloy predecessors. It was estimated that the upgrades will cost the Canadian vending industry C$40 million to recalibrate what it calls "coin-acceptance equipment." Changes to the metallic content of circulating coins in Canada have had a negative impact for many in the Canadian coin-acceptance industry. Following the Canadian coin updates, a May 2012 Wall Street Journal article cites the "headaches (and expense) for vending-machine operators and city governments who have to recalibrate their coin slots and local parking meters."

Once again, I thank you for the opportunity to offer comment. And I leave you with this thought: As a small business our costs grow every month and making ends meet gets harder every year. I note that the overall currency produced by the Mint made a profit last year. I would then ask, since you are profitable today, please don't try to increase your margins by eliminating mine. We don't need more Americans in the unemployment line.

Thank you

John Schultz
American Amusement Machine Association
847-290-9088
jschultz@coin-op.org

AAMA'S MISSION:
TO PRESERVE, PROTECT AND PROMOTE THE COIN-OPERATED ENTERTAINMENT INDUSTRY

5.18.2. NAMA

United States Mint 801 9th Street, NW Washington, DC 20001

This letter is in response to your recent request, included in the Federal Register, for comments on potential alternative metal compositions for circulating coinage pursuant to the Coin Modernization, Oversight, and Continuity Act of 2010 (Pub. L. 111- 302). I am a businessperson in the vending and refreshment services community and am concerned with the negative impact on my industry and our consumers of any change in circulating coinage.

The industry and my concerns are as follows:

1. Metallic Content Changes Could Create a Financial Burden on Small Business: Changes in the composition of circulating coins has an impact on America's small businesses, especially in the vending and refreshment services industry. Changes will require expensive reprogramming of most coin validators. These changes could cost an estimated $100-$500 per machine in upgrade costs, equaling an estimated burden on the vending industry of between $700 million to $3.5 billion.
2. Metallic Content Updates Could Change the Acceptance Rates of Coins: Changes in metallic content may force coin validator manufacturers to increase the verification security level of coins thereby restricting and lowering the acceptance rate of the genuine coins to protect against counterfeiting or misreading of the coins. This could lead to customer dissatisfaction occurring by apparently good coins being rejected and vending sales will be negatively affected by this rejection.
3. The Mint Must Consider Impact on the Vending Industry in any recommendation to Congress: The Mint's authority to provide research and development for alternative coinage materials is derived from Congress by the CMOCA. This Act requires that in the Mint's research and development it must specifically take into account the impact on the vending industry.
4. The Mint Should Provide a Long Transition and Compliance Period with any Recommendation: If coins changes are recommended by the Mint, the Mint should consider the impact of such changes on affected industries, specifically the vending and refreshment services industry. Changes may require that multiple versions of coins be accepted for many years. Circulation time periods of coins should be considered by the mint when assessing their recommendation on transition and compliance period.

Thank you for the opportunity to participate in this request for comments and our industry looks forward to working together on this and other issues in the future. Please do not hesitate to contact me if I can provide further information as to our industry's concerns.

5.18.3. AMOA

Coin Stakeholders Response
Office of Coin Studies, United States Mint
801 Ninth Street NW, 2nd Floor
Washington, DC 20001

Dear Mr. Cameron:

This letter is in response to your recent request, included in the Federal Register, for comments on potential alternative metal compositions for circulating coinage pursuant to the Coin Modernization, Oversight, and Continuity Act of 2010.

I am a small businessperson, and a member of the Amusement & Music Operators Association, committed to my employees and my community. To put it bluntly, if you change the content of the quarter, I will be forced to make drastic changes to my business that, at best, will negatively affect my ability to grow, and at worst, cause me to close my business and lay off my current employees.

Changing the composition of coins will require expensive modifications to coin mechanisms by the coin-operated amusement industry. For example, if changes to the metallic content occur, this will require expensive reprogramming or replacement of most coin acceptors. Such reprogramming or replacement will require a technician to visit all the locations where I service coin-operated machines and reprogram or replace the coin acceptors. Further, if mechanical changes are made to the coins, such as changes in sizes or weights, then even more expensive changes to coin acceptors will be needed. In almost every case, the coin acceptors will then need to be replaced at significant expense.

Changes in the metallic content of coins will cost coin-op amusement operators between $100-$500 per machine in upgrade costs to accept new coins. It is estimated there are approximately 1 million coin-operated amusement machines in the United States. This equals an estimated burden on the coin-op amusement industry of close to one half a billion dollars. Furthermore, there is no return on investment (ROI) for amusement machine operators on equipment upgrades, causing increased business financial outlays and leading to job losses in America's recovering economy.

A change in the metallic content will also increase the risk of the fraudulent use of counterfeit coins ("slugs") or tokens in our machines, again leading to a loss in revenues.

These losses in revenue not only affect our businesses, but since we generally share our revenues with the locations where we place our machines, there are literally hundreds of thousands of other small businesses which will be negatively impacted as well.

I ask you to look at the Canadian experience. In a cost-savings effort, the new Canadian coins used multi-ply steel technology, which makes them cheaper to mint than their alloy predecessors. It was estimated the upgrades will cost the Canadian vending industry C$40 million to recalibrate what it calls "coin-acceptance equipment." Changes to the metallic content of circulating coins in Canada have had a negative impact for many in its coin-acceptance industry.

Once again, I thank you for the opportunity to offer comment. And I leave you with this: as a small business, we work on thin margins and our costs grow every month, which means making ends meet gets harder every year. I note that the overall currency produced by the Mint made a profit last year. Since you are seemingly profitable now, please don't try to increase your margins by eliminating mine. We don't need more Americans in the unemployment line.

Signed: Bhatani

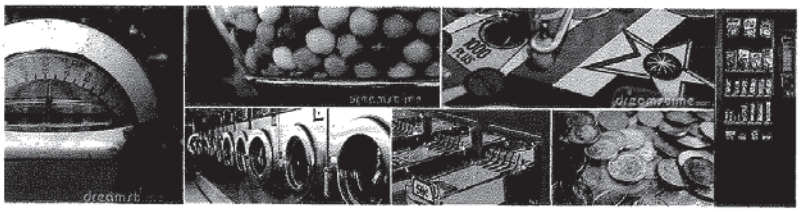
Name: SATINDER BHATANI

Company: ANDAMIRO USA CORP.

Address: 17230 S. MAIN STREET
GARDENA, CA-90248.

5.19. Don't Change Our Change

DON'T CHANGE OUR CHANGE



June 5, 2014

Coin Stakeholders Response
Office of Coin Studies
United States Mint
801 9th St NW, 2nd Floor
Washington, DC 20001

These comments are submitted for the record to the United States Mint, on behalf of the Don't Change Our Change Coalition (DCOC) in response to the recent request, included in the Federal Register, for comments on potential alternative metal compositions for circulating coinage pursuant to the Coin Modernization, Oversight, and Continuity Act of 2010 (Pub.L.111- 302).

Our coalition, Don't Change Our Change, is made of up associations and organizations that primarily represent small business owners, their suppliers, distributors, employees and customers. All of whom will be directly impacted by a change in the composition of circulating coinage. DCOC membership represents all facets of the vending and coin-operated industry. American's enjoy using our machines and equipment in every corner of the country.

Our businesses rely on predictable, standardized coins. Changes to coinage will create an added expense, at best, and could mean the difference between a thriving or failing business for many of our coalition members.

Changes in the metallic content could call for anything from a simple recalibration in vending machines to the installation of new coin-accepting equipment, with a cost that would range from $100-$500 per machine to the outright disposal of the unit. It is estimated that there are approximately 10 million coin operated machines in the United States. This equals an estimated burden to our combined industries of nearly five billion dollars. Furthermore, there is no return on investment for vending operators on equipment upgrades, adding to business financial outlays and leading to job losses in America's recovering economy.

With an introduction of a new composition the issue of co-circulation becomes of great

DON'T CHANGE OUR CHANGE

concern. Also, the uncertainty associated with the length of the transition period recommended by the Mint, poses a significant technological and financial burden on the industry. Within our existing equipment, no mechanism exists that can accept and process coins with different electronic signatures. Do to this, operators and customers will experience faulty machines and these same operators will have to significantly increase their service operations without seeing a direct financial benefit. It is not out of the realm of expectations to assume that should breakdowns frequently occur, machines will be pulled from service harming business owners and limiting consumer choice.

It is important to recognize that the U.S. Mint produces a profit from its overall coin manufacturing business; and therefore shouldn't make imprudent changes at the expense of small businesses that rely on predictable, standardized coinage. In fact, changes made without careful consideration, in an attempt to cut costs, could actually lead to a net loss with loss of business tax revenue and increased cost for educating the public on the new coins.

We appreciate the underlying theme and goal of this study; that the American government should look for ways to save taxpayers dollars. This notion is shared, not just by our members, but also by taxpayers across the country. Yet for our members and the industry we represent, proposed changes to the size and content of coinage will result in severe economic harm, for very little, if any, economic gain to the American taxpayer and government.

Thank you, once again for the opportunity to comment.

5.20. Small Businesses

From: Michael Finkelstein [mailto:michaelfinkelstein717@gmail.com]
Sent: Thursday, April 10, 2014 7:19 PM
To: Coin.StakeholdersResponse@usmint.treas.gov
Subject: testimony by Michael Finkelstein of Associated Services Corporation Laundromat operator

Associated Services Corporation has been in business since 1959 operating coin laundries in the states of Virginia and North Carolina. We are considered one of the larger operators of coin laundries in the area.

I am the President and CEO of this corporation and have been in this position for over the past 10 years. We strive to make our laundries the cleanest, nicest, safest laundries in the towns we operate in.

In 2005 we elected to have all of our equipment operate only on quarters and in increments of 25 cents. This includes Washing machines, dryers, soft drink machines, video games, and snack machines.

We offer change machines in all of our stores which give out only quarters.

This strategy has served us well and a lot of the other coin laundries who I have talked to have adapted a similar strategy(accepting quarters only and pricing in 25 cent increments).

I believe over 90% of all Laundromat operators in the US work on coins(mostly quarters) according to the Coin Laundry Association.

Over the past couple years we implemented in about 15% of our locations a system that also takes both credit card/debit card payments in addition to quarters. The credit/debit card system currently account for about 3% of our total revenue but is growing. It is not accepted universally and demographics do play a part. Limited internet access in rural counties also plays a part in the ability to provide this service.

I think there are about 5% of Laundromat operators(according to the Coin Laundry Association) that use a loyalty card system and accept only bill currency in a central machine. The washers dryers etc. operate off of a card that is purchased at the kiosk where the bills are deposited. Some of these systems can also accept credit/debit payments.

There are also some laundry operators that work only on dollar coins(less than operators who use quarters or loyalty card use according to the Coin Laundry Association), and their changers give out dollar coins and the machines operate in increments of a dollar.

Currently from my perspective the only thing that pennies, nickels, and dimes do is jam up my machines.
The information I have provided is based not only on my locations, but also in discussions as a current board member volunteer of the Coin Laundry Association. This observation is based on the information I have been able to determine from discussing this matter with other CLA members.

Based on our conference call in February with the US Mint it appears that there is deficit spending on producing pennies and nickels. This should be the only area the mint should focus on as if the dime and quarter are not broken the mint should not try to fix it !

If the mint were to eliminate this form of currency it would have virtually no impact on my business or impact my customers.

If however the US Mint were to eliminate quarters, or change the weight, diameter, or its metal contents in a quarter then that would have a HUGE impact on me and my customers as well as my suppliers. It would also negatively impact most other Laundromat operators throughout the US too!

The way a quarter either drops in a washer or dryer or slides in a top load washer is critical to the operation of the equipment. If the US Mint were to alter this coin in any of the ways mentioned(weight, size or component make up) it could cause a machine to malfunction.

If the quarter coin is altered requiring me to retrofit all our equipment it would be terrible.

I project that the labor, and parts needed(that are not yet produced so this is a guestimate) would cost my company about $1,250,000 to adjust over 4000 machines(if it could be done with a new part, drop, or slide). This does not include retrofitting or purchasing new counters in order to get the quarters fed ready for collection.

This is a HUGE expense to us and since most Laundromat operators are 1 or 2 store small business folks it would cause extreme hardship on them and on our industry.

It also impacts companies who transport coin currency such as Brinks, Loomis, us, and other Laundromat operators if new quarters were phased in. It would also pose a HUGE problem as these coins are weighed as a security option when transporting currency. These bags of quarters need to be "fed ready" when these companies pick up for bank deposit.

In closing if there is one thing that is taken away from this testimony it is to PLEASE DO NOT CHANGE THE QUARTER (in size shape weight or component) as it is not losing money for the mint! Focus on the problem at hand which are pennies and nickels which are losing money!
Thank You

- - - - - - - - - - - - - - - - - - -

From: koa4fun@gmail.com [mailto:koa4fun@gmail.com]
Sent: Wednesday, June 04, 2014 1:47 PM
To: Inquiries
Subject: Response to request for comments on potential changes to coin content

Donna Bridges
15020 Hwy 187 S
Eureka Springs, AR 72631-9115

June 4, 2014

Acting Director Richard A. Peterson
801 9th Street, NW
Washington, DC 20220

Dear Acting Director Peterson:

As a small business owner I am writing in response to the recent Notice with Request for Comments on the effects of changing qualities such as weight, color and electromagnetic signature of our circulating coinage.

I appreciate the desire to reduce the costs associated with manufacturing coins, however changing the make-up or size of coins would have a detrimental impact to my business.

Any change to coinage will result in increased costs to update equipment, and address issues with co-circulation of the old and new currencies.
These costs may affect my business's ability to grow and create jobs.

It is estimated changes in the metallic content or size of coins will cost coin operated machine operators between $100 and $500 per machine in upgrade costs to accept new coins. For my business alone that could mean $10-15,000 in expenses.

Finally, while I have spoken to the effects a proposed change would have on our industry, I would also like to comment on the loss to the US Treasury such a change in content would cause. As I understand it, any mechanical or software upgrade to machines in our industry would be counted against ordinary income that small businesses pay taxes on. The ability to write these expenses off would result in a significant shortfall in tax revenues to the Federal Government and would add to our deficit.

Every American taxpayer appreciates your efforts to find ways to save the government money. But this change to our change is simply not worth it. It will kill jobs, punish small business and ultimately result in an added expense to government not a savings.

Sincerely,

Donna Bridges
4792538036

- -

From: Wash & Spin Coin Laundry <washnspin@gmail.com>
Sent: Thursday, May 22, 2014 12:10 PM
To: Coin.StakeholdersResponse
Subject: Effect of Change to Our Quarter

To Whom It May Concern,

I am an owner of a large coin operated laundromat in Atlanta, GA. I am writing to share information about how any alteration of the existing quarter would affect our business. We are very concerned about a potential change since it would adversely affect us. We have a total of 91 washers and dryers, a soap dispensing machine, a quarter dispensing machine and gumball/candy machines that all utilize quarters. The cost to modify or to even replace this equipment would represent an enormous hardship to our struggling business.

The cost to modify the washers and dryers could be hundreds of dollars each, making that total cost $27,000 (assuming $300 times 91 machines). Purchasing a new change machine would be approximately $3,000. We would need to add another $600 to change the soap dispenser and the gumball/candy machines, but possibly more if the manufacture of the soap dispenser doesn't or cannot offer an option of modifying the soap dispenser. The soap dispenser costs approximately $2,300 to replace. We estimate the total potential cost to our business to be between $30,600 - $32,600. This represents a significant portion of our annual sales and would create an extreme financial hardship and jeopardize our ability to employ our 5 workers and to provide the service to our low-income community.

Please do not change the current design of the quarter. It is our number one coin in our store and in our industry. We are a business that provides a public health service to under-served communities. Making any adjustment to the quarter would provide a financial hardship and risk our ability to remain profitable.

Thank you so much for your attention.

Kind Regards,
Yvette Morton Williams
Wash & Spin Coin Laundry
Atlanta, GA

- -

From: Shawn Redd <shawntredd@gmail.com>
Sent: Tuesday, April 15, 2014 3:27 PM
To: Coin.StakeholdersResponse
Subject: Don't Change the Quarter

Hello,

I would like to voice my concern regarding possible changes to the Quarter. I operate a coin laundry in Dilkon, Arizona on the Navajo Nation, Indian Reservation. Due to our remote location our business is a break even operation that barely keeps in operation. It is important to the local community that it serves allowing them to do locally what would otherwise entail a few hours commute time further straining their limited resources.

Retrofitting of our equipment to accept new coin versions would likely prove to be cost prohibitive.

I understand that all entities are looking to save money in their operations. But I feel the current quarter is already earning its way in the world and should not be altered. Quarters are the most functional of the coins in that they are used by vendors all across the country. They hold up well and endure a long service life. Current composition is more than profitable.

Please leave the quarter as is.

Regards,
Shawn Redd
Redd's Laundry
HC 63 Box L
Dilkon, AZ 86047

- -

From: Coastal Coin Laundry <coastal.coin@bellsouth.net>
Sent: Tuesday, June 17, 2014 8:17 PM
To: Coin.StakeholdersResponse
Subject: Proposed change to the US Quarter

As a small business owner of a laundry which is dependent upon the quarter as the denomination to do business, any change in the composition or size of the quarter is a very costly expense for us. It effectively constitutes TAXATION. Let me draw you a picture of the impact this will have on our operation and that of every other business which relies on the US quarter.

1. The coin slots in every one of our 35 machines will no longer work
2. The vending machine will no longer work
3. The video games will no longer work
4. The coin change machine will no longer work
5. The arcade games will no longer work
6. The soap dispensing machine will no longer work

Any change will effectively either put us out of business or cost us 1000s of **Dollars** for retrofitting these machines.

I read the article indicating that the quarter is the most profitable denomination in the mint and that it is actually manufactured for under the 25 cent face value. So why is the mint/government/bureaucracy going to mess with a something that is already profitable and is not broken?

Please rethink this proposed redesign of the quarter with consideration for the impact it will have on our economy: toll booths, vending machines, car washes, marquis, arcades, all the coin counting machines (i.e. banks and vendors) ...just to name a few. Whoever is proposing this change has misplaced priorities.

Respectfully,

Ken Meyer

Alternative Metals Study
Phase II

Technical Report

2014 Biennial Report to the Congress

United States Mint

Department of the Treasury

FINAL

August 11, 2014

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I. Executive Summary

The Coin Modernization, Oversight, and Continuity Act of 2010, Public Law 111-302 (CMOCA) authorizes the Secretary of the Treasury to conduct research and development on "possible new metallic materials or technologies for the production of circulating coins." CMOCA also specifies that before the second anniversary of its enactment, and biennially thereafter, the Secretary of the Treasury shall submit a report to Congress, analyzing production costs for each circulating coin, cost trends for such production, and possible new metallic materials or technologies for the production of circulating coins.

After Phase I concluded in December 2012, the United States Mint (Mint) delivered the first biennial report to Congress, and then continued its research into alternative metals, rejecting some of the materials recommended in that report, and identified six materials that would form the major effort for continued testing in Phase II. Beyond those six compositions, however, the Mint continued to consider and evaluate other, potential, alternative materials.

For Phase II testing, the following materials were evaluated:

	Material	Composition	Tested On
1	Copper-plated zinc (CPZ)	Copper plated on zinc (identical to current one-cent)	Five-cent
2	Tin-plated CPZ (TPCPZ)	Tin plated on copper plated on zinc	Five-cent
3	Nickel-plated steel (NPS)	Nickel plated on low-carbon steel	Five-cent Quarter-dollar*
4	Multi-ply-plated steel (MPPS)	Nickel plated on copper plated on nickel plated on low-carbon steel	Five-cent Quarter-dollar
5	Stainless steel	Austenitic (non-ferromagnetic) stainless steel, monolithic	Five-cent
6	80/20 cupronickel (80/20)	80% copper, 20% nickel, monolithic	Five-cent**

* Materials were tested on the quarter-dollar with the intent of applying those results to the dime and half-dollar.

** 80/20 was only tested on the five-cent but was expected to be clad to copper for higher denominations if it passed.

The Mint chose the top five listed as "co-circulate" materials, meaning the Mint recognized that the material would not have the same electromagnetic signature (EMS) or piece weight as the material of same-denomination coins that are currently in circulation (current material). The Mint chose 80/20 as a "seamless" material, meaning the Mint expected the

material to match the current material's EMS and weight, and have no appreciable impact on the coin-accepting industry.

The Mint purchased all materials except stainless steel in variability lots, which were laboratory-produced and contained 500–2,000 pieces made to specifications to provide the expected range of material properties in production. The supplier provided multiple configurations, typically modifying the key variable such as plating thickness, to provide the Mint with samples that would span the normal variation to be expected in production material. Those materials that passed the variability lot testing were then purchased in pre-production lots, which were much larger, typically about 2 million pieces. Pre-production lots were produced on the supplier's normal manufacturing lines over separate production runs to evaluate material that would be representative of actual production.

During variability testing, materials were processed through progression strikes to show how varying strike force (in metric tons, or tonnes) would affect the material's detail ("fill") as compared with the current coins. The Mint also put test pieces through a two-week accelerated wear test, a steam test designed to test the material's resistance to color change, and various other tests, such as conductivity, hardness, and EMS. Then, the materials had to pass a Go/No-Go determination on seven criteria.

TPCPZ and CPZ both failed their Go/No-Go determinations because of poor results on the wear test. NPS and MPPS passed their Go/No-Go criteria for both the five-cent and the quarter-dollar and the Mint purchased those materials for pre-production testing. As the Mint had not finalized security requirements of the quarter-dollar at that time, it purchased NPS and MPPS for the quarter-dollar. Stainless steel was the subject of a Feasibility Study at the time, and had not yet reached the Variability stage as the other co-circulate materials had.

The original 80/20 material's EMS did not match the current material. However, a slightly modified version of the 80/20 material, which substituted manganese for some of the nickel to achieve the conductivity and EMS of the current material, showed promise. Accordingly, the Mint procured about 500 pieces of this modified 80/20 to run it through the progression strikes, wear test, and steam test. The Mint also tested the modified 80/20's EMS at three different external coin acceptor manufacturers that all confirmed an EMS match with the current material. The Mint determined that modified 80/20 passed its Go/No-Go criteria and, accordingly, it purchased additional quantities for pre-production testing.

The Mint purchased NPS and MPPS in five-cent and quarter-dollar configurations and the modified 80/20 (from this point on in the Executive Summary, referred to as "80/20") in five-cent configuration for the pre-production testing. Initially, NPS and MPPS proved to have poor striking qualities in the variability testing. However, the Mint consulted with The Royal Mint (RM) and the Royal Canadian Mint (RCM), both of which have experience with these cold-rolled[1], low-carbon, plated-steel materials, and identified various changes to mitigate these issues. In addition, the Mint had to send nonsense dies (some polished to ascertain the effects of die surface preparation on striking) to RM and RCM for physical vapor deposition (PVD) coating to enable dies to withstand the severe abrasion associated with nickel plating on both of these products.

The RM and RCM sent to the Mint quantities of both materials, which showed improvement, but the Mint still had problems with die life and fill. After more interaction with the RM and RCM, the Mint received pre-production lots and conducted full tests on both plated-steel materials. The die life still proved significantly less than with the current material. The Mint determined that noticeable changes to the coin aspects (including adjustment to the height of relief/crown, smoothing design features, softening letters, and less-detailed images in general) would be needed to improve coinability. In addition, planchet profiles and blank lubrication would need optimization. The tests suggest that the plated-steel materials will not surpass or even match the current material in coinability.

The Mint also investigated stainless steel as a co-circulate option, either as a monolithc material for the five-cent, or as a clad material for the dime, quarter-dollar, and half-dollar. The security requirements of the quarter-dollar (and higher denominations) make this easily-counterfeited material unsuitable for those denominations, though it would be feasible for the five-cent. Further testing would be required to determine its feasibility for cladding the dime.

The Mint is still researching other alternatives to the ones already tested in this report. Of note are coins made of a variation on "nickel silver," a material composed of copper, nickel, and zinc that has a silver appearance. The variation, alloy C77000, is expected to yield a coin that has the same EMS as current coins, and (similar to the 80/20 alloy) has a weight that falls into the acceptable variation on current coins. The Mint is partnering with the National

[1] Rolling is a metal process in which metal stock is pressed through one or more pairs of rollers to reduce the thickness of the metal. Cold-rolled indicates that the rolling was at a temperature in which the metal grains do not recrystallize; the absence of recrystallization reduces the material's ability to deform under stress (ductility).

Institute of Standards and Technology (NIST), a bureau of the Department of Commerce, to pursue an alloy development project.

The Mint is also investigating plated coins that use a silicon-steel core, not used elsewhere in the world, that could have a unique EMS. Silicon steel is commonly referred to as "electrical steel" and has a similar price to low-carbon steel.

Tables I-1 and I-2, on pages vii and viii, provide a performance summary of the co-circulate materials in the Down Selection, first for the five-cent, and then for the quarter-dollar.

The charts show that MPPS and NPS have superior durability compared with the current material. However, MPPS and NPS were less coinable than the current material; were not as recyclable; were more vulnerable to counterfeiting and fraud; and MPPS is only available from the RCM, unlike the other candidate materials and the current material, which all have multiple suppliers. This makes NPS and MPPS feasible for the five-cent, but (due to security requirements) not feasible for the quarter-dollar.

External Studies

During the course of Phase II, the Mint contracted Concurrent Technologies Corporation (CTC), which had conducted Phase I of the Alternative Metals Study in 2010–2012, to evaluate the potential use of bi-metallic coin construction for U.S. coins, and to study the feasibility of stainless steel for use in U.S. coins. The Mint also contracted Fraunhofer USA, a company that specializes in applied research for government and industry customers, to research laser-blanking as a production improvement at United States mints.

All three reports are attached to this report, and their executive summaries are in Sections 7 (Bi-Metallic Coins), 8 (Stainless Feasibility), and 9 (Laser-Blanking).

Findings and Conclusions

Two separate types of alternatives were considered during Phase II testing/evaluation. The first was a material with an EMS and piece weight that was potentially seamless with the current material. The second were co-circulate alternatives in which the EMS differed from the current material and the piece weight would vary from the current material by 4 percent or more.

Potentially seamless alternatives would not require changes to the coin acceptors, but would only offer modest annual savings (approximately 3 percent). Co-circulate alternatives provide much greater annual savings (up to approximately 20 percent), but would require significant stakeholder conversion costs to accommodate the different EMS and piece weight.

- Potentially seamless alternative evaluated: 80/20
- Co-circulate alternatives evaluated: Nickel-plated steel (NPS)
  Multi-ply-plated steel (MPPS)
  Stainless steel
  Copper-plated zinc (CPZ)
  Tin-plated CPZ (TPCPZ)

Seamless Material

1. A variant of today's current cupronickel composition, termed 80/20, which has a lower nickel content with higher manganese, was found to be seamless when tested by three separate coin-acceptor manufacturers.[2] The Mint estimated this material would provide approximately $5.25M annual savings ($3.2M for the five-cent, $0.8M for the dime, $1.25M for the quarter-dollar) with no impact on the public or on stakeholders.

2. 80/20 matches the current material in both EMS and in piece weight, having a weight that falls within legally accepted variances for the current material.

3. Initial testing of other, potentially seamless, leaner-copper alternatives shows potential for further incremental material savings.

[2] In testing, treated 80/20 five-cent pieces were 100% accepted by all three coin-acceptor manufacturers.

Co-Circulate Materials

4. Plated-steel materials are a viable option for the five-cent and potentially the dime, and offer up to approximately $29M in savings annually over current materials. However, plated-steel materials have increased risks of fraud and counterfeit, and are used in low-value foreign coins, all of which make the materials not feasible for use in the quarter-dollar. They also have a significantly lower die life, which, if not mitigated (see #6, below), could increase production and labor costs, and reduce the savings the materials might offer.

5. Stainless steel, while resistant to corrosion, has a hardness that can negatively impact its coinability. Control of cold-rolling reduction and proper annealing of the right grades demonstrated the ability to mitigate this factor, and improves the coinability of stainless steel. (See attached Stainless Feasibility Study and its Executive Summary in Section 8.)

Production Improvement

6. The Mint explored options of adjusting the height of the relief and crown on the current coin design to address unacceptable fill on some materials. However, this change introduced other issues, such as outer elements (e.g., the border) filling before inner ones, or the flow of the material changing. It became clear that changes to the coin features—including adjustments to the height of relief/crown, planchet profile, smoothing of design, softening of the letters, and less-detailed images in general—must be treated as a collective system. This system involves not only the items mentioned here, but also matching planchet-die geometry, strike force, die lubrication/coating/polishing, and other variables.

Terminated Materials

7. Testing of plated zinc alternatives (copper-plated zinc (CPZ) and tin-plated copper-plated zinc (TPCPZ)) showed insufficient wear and durability properties for consideration on denominations other than the current one-cent CPZ application. Additionally, TPCPZ exhibited galvanic corrosion when copper and tin, two dissimilar metals, were exposed to the environment during wear, rendering this construction unsuitable for any U.S. coins.

Table I-1. Five-Cent Down-Select Summary

5-Cent Down-Select Summary				
Factor	Description	Material Composition & Unit Cost		
		NPS	MPPS	Stainless 3XX
	Current Unit Cost $0.0787 (FY14 Unit Costs through March 2014)	$ 0.0611	$ 0.0550	$ 0.0583
Environmental Impact	No change or better compared to current for internal operations and external fabricator	Comparable or Better	Comparable or Better	Comparable or Better
Supply Chain	There is future availability of the metal and a competitive supply chain - more than one fabricator/supplier	Comparable or Better	Less than Current	TBD
Coinability	Crack/piece-out incidences are less than or equal to our current, die life is acceptable	Less than Current	Less than Current	TBD
Recyclability	Ease of recycling and value of metal recovery	Less than Current	Less than Current	Comparable or Better
Durability	Tarnish and corrosion resistance; acceptable durability/wear	Comparable or Better	Comparable or Better	Comparable or Better
Counterfeit/Slug Vulnerability	Uniqueness among world coins, limited use of lesser value foreign coins, tokens or easily produced counterfeit devices	Less than Current	Less than Current	Less than Current
Applicability for U.S. Circulating Coinage		**Feasible**	**Feasible**	**TBD**

Table I-2. Quarter-Dollar Down-Select Summary

Quarter-Dollar Down-Select Summary			
Factor	Description	Material Composition & Unit Cost	
		NPS	MPPS
	Current Unit Cost $0.0912 (FY14 Unit Costs through March 2014)	$ 0.0676	$ 0.0651
Environmental Impact	No change or better compared to current for internal operations and external fabricator	Comparable or Better	Comparable or Better
Supply Chain	Future availability of the metal and a competitive supply chain - more than one fabricator/supplier	Comparable or Better	Less than Current
Coinability	Crack/piece-out incidences are less than or equal to our current, die life is acceptable	Less than Current	Less than Current
Recyclability	Ease of recycling and value of metal recovery	Less than Current	Less than Current
Durability	Tarnish and corrosion resistance; acceptable durability/wear	Comparable or Better	Comparable or Better
Counterfeit/Slug Vulnerability	Uniqueness among world coins, limited use of lesser value foreign coins, tokens or easily produced counterfeit devices	Less than Current	Less than Current
Applicability for U.S. Circulating Coinage		**Not Feasible**	**Not Feasible**

Technical Recommendations for Further Study

1. Continue 80/20 Testing and Evaluation
    a. Continue larger-scale testing of 80/20 and develop a final specification that can be utilized by current and other strip suppliers.
    b. Conduct feasibility, variability, and pre-production testing on cladding 80/20 to a copper core as an alternative for the clad denominations of dime, quarter-dollar, and half-dollar. The primary benefit of this is the streamlining of the material production.
2. Pursue seamless alloy development

    Continue alloy development of other, potentially seamless, leaner-copper alternatives to provide opportunity for additional incremental materials savings without impacting coin acceptors and coin processors. Initial testing indicates further opportunity for incremental material cost reductions with a composition evolving over several progressive steps.
3. Continue stainless steel R&D
    a. Continue larger-scale variability and pre-production testing on the two stainless steel grades identified in the attached Stainless Feasibility Study: Rittenhouse 52 and 18-9LW.
    b. Conduct testing and evaluation of monolithic stainless steel as a clad outer layer as a co-circulate material. Engineering calculations indicate this combination could exhibit a similar EMS to the current clad coins and enable the copper core thickness to be reduced, providing incremental material savings and a reduction in the use of the more-expensive and price-volatile nickel. Its piece weight, however, would be lighter.
4. Explore production improvements
    a. Investigate push-back blanking and determine if that is a technically feasible and cost-effective production method that would enable elimination of internal annealing on strip material (see attached Laser-Blanking Study).
    b. Pursue more-structured test strikes on different coin materials, modified design aspects, and upset profile configurations to increase the Mint's understanding of the overall coin manufacturing system. These results can be utilized to improve production efficiencies on current coin materials and provide for quicker evaluation of future materials. Results from structured trials can be used to support predictive model development and reduce the need for time-consuming iterative test strikes.

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II. Table of Contents

I. Executive Summary i

II. Table of Contents xi

III. Table of Figures xvi

IV. Table of Tables xvii

1. Introduction 1

1.1. Background ... 1

1.2. Public Law ... 2

1.3. Costs ... 2

1.4. Summary of Phase I ... 5

1.4.1. Alternative Metals Considered but Eliminated ... 5

1.4.2. Alternatives to Production ... 7

1.4.3. Proposed Action ... 8

1.5. Phase II ... 10

1.5.1. Introduction ... 10

1.5.2. Objective ... 10

1.5.3. Testing ... 11

1.6. Other Research and Development ... 12

1.7. Testing Facilities ... 13

1.8. Independent Peer Review ... 14

1.8.1. Argonne Report Executive Summary ... 15

1.9. Public Law 111-302 ... 17

2. Materials 19

2.1. Introduction ... 19

2.1.1. Raw Metals ... 19

2.1.2. Other Considerations ... 24

2.2. Approach ... 25

2.3. Key Features ... 26

2.3.1. EMS ... 26

2.3.2. Weight 27
2.3.3. Color 27
2.3.4. Construction 28
2.3.5. Hardness 29
2.4. The Materials 31
2.4.1. Current 31
2.4.2. 80/20 Cupronickel 31
2.4.3. Copper-Plated Zinc (CPZ) 32
2.4.4. Multi-Ply-Plated Steel 32
2.4.5. Nickel-Plated Steel 33
2.4.6. Stainless Steel 33
2.4.7. Tin-Plated Copper-Plated Zinc (TPCPZ) 34
2.5. Cost 34
2.6. Sourcing 38
3. Testing 39
3.1. Control Plan and Procedures 39
3.1.1. Control Plan 39
3.1.2. Procedures 39
3.2. Steps 40
3.2.1. Progression Strikes 40
3.2.2. Testing Results 41
3.2.3. Wear Test 41
3.2.4. Steam Test 42
3.2.5. Coin Sorter/Validator (CSV) Test 43
3.2.6. Hardness Test 44
3.2.7. Electrical Conductivity Test 45
3.3. Material Tests – Variability Lots 46
3.3.1. CPZ (Variability Lot) 46
3.3.2. Tin-Plated Copper-Plated Zinc (Variability Lot) 51
3.3.3. Multi-Ply-Plated Steel (Variability Lot) 56

3.3.4. Nickel-Plated Steel (Variability Lot) 62
3.3.5. Cupronickel 80/20 from Supplier A (80/20A) (Variability Lot) 68
3.3.6. Cupronickel 80/20 from Supplier B (80/20B) (Variability Lot) 71
3.4. Pre-Production Testing 74
3.4.1. CPZ Pre-Production Data 74
3.4.2. Down-Selection Matrices 74
3.4.3. Multi-Ply-Plated Steel (Pre-Production Lot) 80
3.4.4. MPPS Down-Selection 83
3.4.5. Nickel-Plated Steel (Pre-Production Lot) 85
3.4.6. NPS Down-Selection 89
3.4.7. Cupronickel 80/20B (Pre-Production Lot) 91
3.4.8. 80/20B Down-Selection 93
4. U.S. Coin Security 95
4.1. Threats 95
4.1.1. Counterfeiting 95
4.1.2. Fraud 95
4.2. Security Features of U.S. Coinage 96
4.2.1. Background 96
4.2.2. Variances in Conductivity/EMS 97
4.2.3. Coin Construction 98
4.2.4. Coin Security Evolution 98
4.3. Steel-Based Coin Security 99
4.3.1. Plated Steel 101
4.3.2. Stainless Steel 103
4.3.3. Homogeneous Materials 104
4.3.4. Coin Sorter/Validator Testing 104
4.4. Steel-Based Coin Security Conclusions 106
5. Coinability 107
5.1. Testing Methods 107
5.2. Baseline Results 108

5.2.1. 80/20B Five-Cent 110
5.2.2. Multi-Ply-Plated Steel (Five-Cent) 113
5.2.3. Multi-Ply Plated Steel Quarter-Dollar 115
5.2.4. Nickel-Plated Steel Five-Cent 117
5.2.5. Nickel-Plated Steel Quarter-Dollar 119
5.3. Conclusions 123
6. Findings/Conclusions and Recommendations 125
6.1. Findings and Conclusions 125
6.2. Recommendations for Further Study 128
7. Bi-Metallic Coin Study 129
7.1. Executive Summary 129
8. Stainless Steel Feasibility Study 137
8.1. Executive Summary 137
9. Laser-Blanking Study 139
9.1. Executive Summary 139
10. Appendices 147
10.1. Wear Test Results – Variability Lots 147
10.1.1. Copper-Plated Zinc (CPZ) 147
10.1.2. Tin-Plated CPZ (TPCPZ) 148
10.1.3. NPS 150
10.1.4. MPPS 152
10.1.5. 80/20A (Variability) 154
10.1.6. 80/20B (Variability) 155
10.2. Steam Test Results – Variability Lots 156
10.2.1. CPZ Steam Test 156
10.2.2. TPCPZ Steam Test 157
10.2.3. NPS Steam Test 159
10.2.4. MPPS Steam Test 161
10.2.5. 80/20A Steam Test (Variability) 163
10.2.6. 80/20B Steam Test (Variability) 164

10.3. Conductivity and CSV Test Results – Variability Lots 165
10.3.1. CPZ Conductivity and CSV 165
10.3.2. TPCPZ Conductivity and CSV 168
10.3.3. NPS (Conductivity Test Not Applicable) 176
10.3.4. MPPS (Conductivity Test Not Applicable) 178
10.3.5. 80/20A (Conductivity Results Unavailable) 180
10.3.6. 80/20B (Conductivity Results Unavailable) 181
10.4. Wear Test Results – Pre-Production 182
10.4.1. NPS 182
10.4.2. MPPS 186
10.4.3. 80/20B 188
10.4.4. CPZ 190
10.5. Steam Test Results – Pre-Production 191
10.5.1. Nickel-Plated Steel 191
10.5.2. MPPS 195
10.5.3. 80/20B 197
10.5.4. CPZ 199
10.6. CSV Test Results – Pre-Production 200
10.6.1. NPS 200
10.6.2. MPPS 204
10.6.3. 80/20B 206
10.6.4. CPZ 207
10.7. CSV Comparison—Plated Steel v. Current Material 208
11. Acronym List 209

III. Table of Figures

Figure 1-1. Historical Unit Cost of the One Cent 3
Figure 1-2. Historical Unit Cost of the 5 Cent 3
Figure 2-1. Commodity Price History of Nickel, 1999 to 2014 19
Figure 2-2. Commodity Price History of Copper, 1999 to 2014 20
Figure 2-3. Commodity Price History of Zinc, 1999 to 2014 21
Figure 2-4. Commodity Price History of Aluminum, 1999 to 2014 22
Figure 2-5. Commodity Price History of Steel Billet, 2008 to 2014 23
Figure 2-6. Quarter-Dollar Nonsense Test Pieces 25
Figure 2-7. Electroplating 28
Figure 2-8. Damaged Die 30
Figure 3-1. R&D Coining Press 40
Figure 3-2. Steam Test Tumblers 41
Figure 3-3. Steam Test Autoclave 43
Figure 3-4. High-Speed CSV 43
Figure 3-5. Hardness Tester 44
Figure 3-6. CPZ Test Piece 46
Figure 3-7. 5 Cent CPZ Blank Color Change—Variability Lot 47
Figure 3-8. 5 Cent CPZ Planchet Hardness Test—Variability Lot 48
Figure 3-9. CPZ After Wear Test 49
Figure 3-10. 5 Cent TPCPZ Blank Color Change—Variability Lot 51
Figure 3-11. Quarter Dollar TPCPZ Blank Color Change—Variability Lot 52
Figure 3-12. 5 Cent TPCPZ Planchet Hardness Test—Variability Lot 52
Figure 3-13. Quarter Dollar TPCPZ Planchet Hardness Test—Variability Lot 53
Figure 3-14. TPCPZ After Wear Test 54
Figure 3-14. MPPS 5-Cent Test Piece 56
Figure 3-15. MPPS Quarter-Dollar Test Piece 57
Figure 3-16. 5 Cent MPPS Blank Color Change—Variability Lot 57
Figure 3-17. Quarter Dollar MPPS Blank Color Change—Variability Lot 58
Figure 3-18. 5 Cent MPPS Planchet Hardness Test—Variability Lot 58

Figure 3-19. Quarter Dollar MPPS Planchet Hardness Test—Variability Lot 59
Figure 3-20. MPPS Quarter Dollar After Wear Test 61
Figure 3-21. NPS 5-Cent Test Piece 62
Figure 3-22. NPS Quarter-Dollar Test Piece 63
Figure 3-23. 5 Cent NPS Blank Color Change—Variability Lot 63
Figure 3-24. Quarter Dollar NPS Blank Color Change—Variability Lot 64
Figure 3-25. 5 Cent NPS Planchet Hardness Test—Variability Lot.....64
Figure 3-26. Quarter Dollar NPS Planchet Hardness Test—Variability Lot 65
Figure 3-27. NPS Quarter Dollar After Wear Test.....66
Figure 3-28. 80/20A Test Piece (54T Strike).....68
Figure 3-29. 5 Cent 80/20A Planchet Hardness Test—Variability Lot.....69
Figure 3-30. 80/20A After Wear Test 70
Figure 3-31. 80/20B Test Piece (54T Strike) 71
Figure 3-32. 5 Cent 80/20B Planchet Hardness Test—Variability Lot 72
Figure 3-33. 80/20B After Wear Test.....73
Figure 3-34. MPPS 5-Cent Test Piece (56T Strike) 80
Figure 3-35. MPPS Quarter-Dollar Test Piece (64T Strike) 81
Figure 3-36. 5 Cent MPPS Blank Color Change—Pre-Production Lot 82
Figure 3-37. Quarter Dollar MPPS Blank Color Change—Pre-Production Lot 82
Figure 3-38. NPS Quarter-Dollar Test Piece (66T Strike) 85
Figure 3-39. NPS 5-Cent Test Piece (Detail) 86
Figure 3-40. 5 Cent NPS Blank Color Change—Pre-Production Lot 88
Figure 3-41. Quarter Dollar NPS Blank Color Change—Pre-Production Lot 88
Figure 3-44. 80/20B Test Piece (54T Strike) 91
Figure 3-45. 5 Cent 80/20Blank Color Change—Pre-Production Lot 92
Figure 4-1. Slugs and Tokens.....96

IV. Table of Tables

Table I-1. 5-Cent Down-Select Summary vii
Table I-2. Quarter-Dollar Down-Select Summary..... viii

Table 1-1. FY2014 Unit Cost of Producing and Distributing Coins, by Denomination.....4
Table 1-2. Eliminated Candidate Metals for Coinage.....6
Table 1-3. CTC-Recommended 5-Cent Alternatives 9
Table 1-4. CTC-Recommended Dime, Quarter-Dollar, and Half-Dollar Alternatives 9
Table 1-5. Average Die-Life Performance (5 Cent) – Philadelphia.....12
Table 1-6. Average Die-Life Performance (Quarter Dollar) – Philadelphia 12
Table 2-1. Phase II Test Program Summary.....26
Table 2-3. Current Material Specifications 31
Table 2-4. 80/20B Specifications.....32
Table 2-5. CPZ Specifications 32
Table 2-6. MPPS Specifications 33
Table 2-7. NPS Specifications 33
Table 2-8. Stainless Steel Specifications 34
Table 2-9. TPCPZ Specifications 34
Table 2-10. Estimated Unit Costs of 5-Cent Candidates 35
Table 2-11. Estimated Unit Costs of Quarter-Dollar Candidates.....36
Table 2-12. Estimated Cost Breakdown – Current and Alternative Metals.....37
Table 4-1. EVA Coin Value Categories 100
Table 4-2. Foreign Plated-Steel Coins 102
Table 4-3. Counterfeit Seizures in China 103
Table 5-1. Baseline Die-Life Determination (5 Cent).....109
Table 5-2. Baseline Die-Life Determination (Quarter Dollar).....110
Table 5-3. Initial 80/20B Die Life (5 Cent).....111
Table 5-3. Treated 80/20B Die Life (5 Cent) 112
Table 5-4. MPPS Die Life (5 Cent) 114
Table 5-5. MPPS Die Life (Quarter Dollar).....116
Table 5-6. NPS Die Life (5 Cent) 118
Table 5-7. NPS Die Life (Quarter Dollar).....121
Table 5-9. Pre-Production Average Die Life 123

1. Introduction

The United States Mint (Mint) is a bureau of the United States Department of the Treasury. Established in 1792, the Mint is the world's largest coin manufacturer. The principal mission of the Mint is to mint and issue circulating coins in amounts that the Secretary of the Treasury decides are necessary to meet the needs of the United States. Current coins in circulation are the one-cent, five-cent, dime, quarter-dollar, half-dollar, and dollar. The half-dollar and dollar are not currently in production for circulation, though the coins remain legal tender.

The Mint is a self-funded agency that issues circulating coins to the Federal Reserve Banks at face value and distributes numismatic products—including collectible coins and sets, bullion coins, medals, and related accessories—at prices established to fully recover their costs.

1.1. Background

Prior to 1965, the four higher denomination coins (dime, quarter-dollar, half-dollar, and dollar) were made of a 90% silver-10% copper (Ag-10%Cu) alloy; the five-cent has been a monolithic[3] copper-nickel (Cu-25%Ni) alloy (also known as "cupronickel") since 1866 (except for a brief change to the composition during World War II).

In 1965, in response to dwindling supplies of silver in the U.S. Treasury, Congress passed legislation that required the Mint to replace silver coins with coins made of the five-cent's cupronickel alloy that was clad to a commercially pure (99.9%) copper core. The Mint recommended these two materials and their relative thickness in the clad formulation because this configuration provided electromagnetic properties that matched current coins in coin acceptors at that time. The weight of the coins was slightly different, but the new coins' lighter piece weight had no appreciable effect on their use in vending.

The one-cent was made of a copper-zinc (Cu-5%Zn) alloy before it was changed to a copper-plated zinc core in 1982, in response to the rising price of copper. Since 1983, the one-cent

[3] Metals are mixed together and are inseparable without smelting.

has been composed of a zinc-copper (Zn-0.8%Cu) alloy core, electroplated with 8 microns[4] (8μm) of pure copper.

In 2006 and 2007, the prices of nickel and copper both rose high enough to make the one-cent and five-cent cost more than their face values. Because of this, since 2007, the United States Mint has maintained regulations, approved by the Secretary of the Treasury under 31 U.S.C. § 5111(d), prohibiting the melting, exportation or treatment of one-cent and five-cent coins.

1.2. Public Law

On November 30, 2010, the U. S. Congress passed Public Law 111-302, the Coin Modernization, Oversight, and Continuity Act of 2010 (CMOCA), which authorized the Mint to research and develop alternative metals for U.S. coins. The President subsequently approved this legislation on December 14, 2010. The intent of CMOCA is to reduce the expense of minting coins while still keeping them secure from fraud and counterfeiting. The act also specifies that, in recommending new metals, the Secretary of the Treasury must consider their impact on the public and stakeholders (vending machine and other coin acceptor manufacturers, vending machine owners and operators, transit officials, municipal parking officials, depository institutions, coin and currency handlers, armored-car operators, car wash operators, laundromats, and American-owned manufacturers of commercial coin-processing equipment). A copy of CMOCA can be found in Section 1.9 of this report.

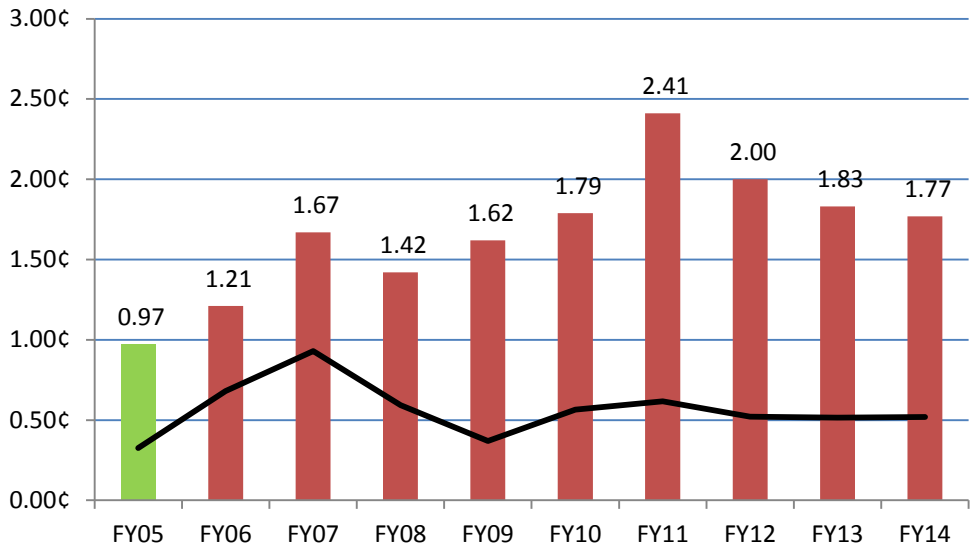
1.3. Costs

Since 2006, both the one-cent and five-cent have cost more to produce than their face value, as shown in Figures 1-1 and 1-2, below. Rising costs of raw materials (shown as the black line in Figures 1-1 and 1-2) have combined with rising fabrication[5] costs to contribute to that imbalance. Conversely, the dime and the quarter-dollar cost less than half their face value to produce as of March 2014, though the costs of their raw materials (cupronickel clad to copper) have also risen. Two reasons these coins' costs are not yet above face value are their

[4] One one-millionth of a meter, or one-thousandth of a millimeter; also called a micrometer; 1μm is roughly equivalent to 0.00003937 inches; for comparison, an average piece of paper is 75μm thick.
[5] Fabrication is the process by which the material is produced by the supplier and may include plating, cladding, and/or alloying, and can also include the cost of rolling.

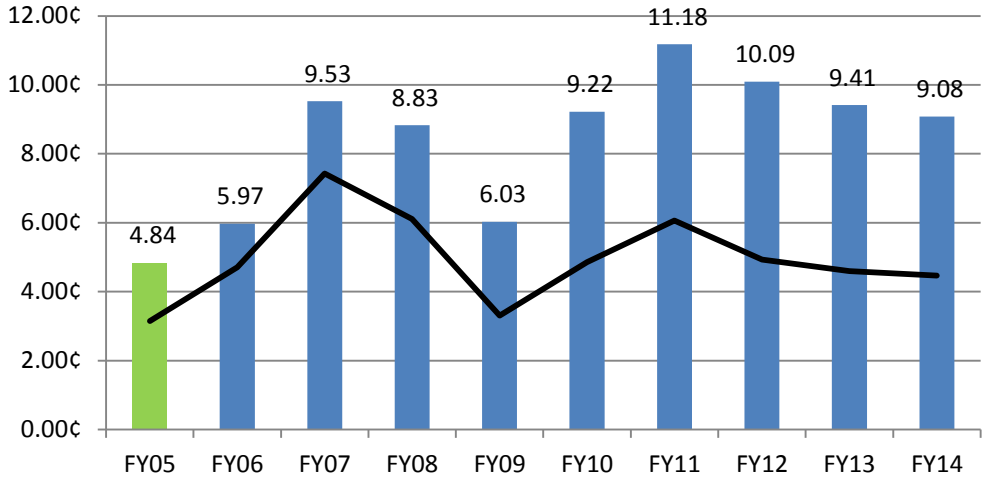
relative size vs. face value and the fact that the majority of the coins' material (two-thirds) is the lower-cost copper core.

Figure 1-1. Historical Unit Cost of the One-Cent



General and Administrative costs were not figured into the one-cent's cost until 2011.
Raw metal costs are the black line; FY14 costs are through March 2014.

Figure 1-2. Historical Unit Cost of the Five-Cent



Raw metal costs are the black line; FY14 costs are through March 2014.

The costs of the one-cent and five-cent coins include more than just the material cost because the Mint does not manufacture materials, but buys them either in rolls of metal strip or as ready-to-strike planchets.

When the material is received in strip form, the Mint first punches out "blanks," or coin-sized discs from the sheet. These blanks are then sent through a furnace in a process called "annealing," which softens the material. After this, blanks are cleaned before the "upsetting" step, which raises the edges of the blank. At this point, the blank is called a "planchet" and is ready to be struck into a coin. All of these steps cost the Mint resources (electricity, water, and tools), time, and money (wages, supplies, etc.).

When the material arrives in planchet form, the supplier has handled all those previous steps, and all that remains for the Mint is to strike the planchets into coins (as is the case with the one-cent). In this case, supplier fabrication costs tend to be slightly higher than coins made from strip, as they include labor and other costs of fabrication to deliver the material in ready-to-strike form.

Mint production costs reflect the amount of work the Mint does to produce each coin; the least amount of work is performed on the one-cent planchets which are received ready to strike (stamp, count, and package). The five-cent, dime, and quarter-dollar all have to be blanked, annealed, cleaned, and upset before they can be struck into coins, and their direct Mint production costs per coin are correspondingly higher, per unit.

In all cases, though, plant overhead costs (heating, electricity, etc.) must be considered. All of these costs add up to what is known as the Cost of Goods Sold (COGS).

Table 1-1. FY2014[6] Unit Cost of Producing and Distributing Coins, by Denomination

	One-Cent	Five-Cent	Dime	Quarter-Dollar
Metal Cost	0.96	4.97	2.39	5.83
Mint Production	0.54	1.51	0.99	1.72
Cost of Goods Sold	***1.50***	***6.48***	***3.38***	***7.55***
General and Administrative	0.28	1.34	0.65	1.46
Distribution to FRB	0.02	0.05	0.04	0.11
Total Unit Cost	**1.80**	**7.87**	**4.07**	**9.12**

Costs are shown in cents.

In addition to the COGS, the Mint incurs costs in simply running the day-to-day operations of Mint offices in support of the coin-making process (general and administrative costs).

[6] Unit costs are FY2014 YTD through March 2014

Finally, the cost of distributing sold coins to the Federal Reserve Banks (FRBs) is also the Mint's responsibility.

1.4. Summary of Phase I

In July 2011, the Mint awarded Concurrent Technologies Corporation (CTC) a competitively bid contract to investigate various alternative compositions for all U.S. circulating coins. The half-dollar, dime, and quarter-dollar all have identical compositions, and of those three denominations, only quarter-dollar nonsense pieces were struck. In addition, testing was performed on the one-cent and five-cent.

1.4.1. Alternative Metals Considered but Eliminated

In determining what materials are suitable for replacing the current ones, the study considered many factors, including:

- U.S. industrial base ability to supply material
- Material availability, now and in the future
- Process consistency at mints and metal producers
- Process capabilities and current capitalization at Mint facilities
- Material prices
- Material price trends
- Available fabrication methods
- Fabrication costs
- Coin die life
- Electromagnetic signature (EMS)
- Wear resistance
- Corrosion resistance
- Color and circulation-based color change
- Coinability (i.e., low flow stress, adequate ductility)[7]
- Work hardening[8]
- Density
- Environmental impact
- Toxicity
- Worker health and safety
- Recyclability
- Construction (plated vs. clad vs. monolithic)
- Security (i.e., counterfeit and fraud resistance)
- Coin-processing equipment (hardware and software)
- Blind and visually-impaired recognition and acceptance
- General public recognition and acceptance
- Co-circulation of current and new coins.

[7] Flow stress is a measure of the force required to permanently deform a metal during forming operations. Ductility is a metal's ability to be worked without cracking, shattering or breaking.

[8] Work hardening is a material response in which the strength of metallic minerals increases due to permanent deformation.

Consideration of all these issues makes the design and selection of a coinage material and the associated production methods a complex, challenging task.

The periodic table contains 91 metals within it (out of 118 total elements). Very early in the project, CTC rejected the majority of those metals from consideration as an alternative coin material for a variety of reasons. The most common reasons were the metal's radioactivity (uranium, plutonium, and thorium) or toxicity (lead, cadmium, and chromium). Of the remaining metals, CTC rejected most for their softness, potentially negative environmental impacts, and/or negative health and safety impacts.

This early review then resulted in CTC eliminating even more potential metals, primarily for high cost, as shown in Table 1-2.

Table 1-2. Eliminated Candidate Metals for Coinage

Element	Element Symbol	Reasons for Elimination
Beryllium	Be	Too expensive; toxic
Bismuth	Bi	Too expensive; multi-colored oxidation
Cobalt	Co	Too expensive; toxic if ingested
Molybdenum	Mo	Too expensive; health issues when metalworking
Niobium	Nb	Too expensive
Tantalum	Ta	Too expensive; rare
Titanium	Ti	Too expensive
Vanadium	V	Too expensive; environmental issues
Tungsten	W	Too expensive; too hard
Zirconium	Zr	Too expensive
Silver	Ag	Too expensive*
Gold	Au	Too expensive*

* - Ag and Au are used for commemorative coins and for bullion.

CTC then considered the London Metal Exchange, other sources of metal prices, and global metal supplies to determine the best possible candidate metals and alloys from those metals that remained (iron, aluminum, zinc, tin, manganese, etc.). They determined steel, zinc, and

aluminum alloys to be the leading candidates to reduce the cost of coinage by replacing nickel and copper, either partially or wholly.

In this process, CTC selected candidate metals for each circulating denomination. Low cost was the clear driver for the one-cent. Security and ease of transition were minor concerns because that denomination is not typically used in vending machines or in other, non-attended, automated points of sale. For all other denominations, two general categories identified the metals and fabrication concepts: potential for seamless transition, with modest cost savings; and potential for non-seamless co-circulation, with significant cost savings.

The candidates for seamless transition had a similar electromagnetic signature (EMS) as the current coins, so disruption of or cost to the vending and coin-processing industries would be minimal. Those candidate materials for the non-seamless transition did not match the EMS of the current materials, but were designed to have an identifiable, unique EMS of their own, whenever possible. This was to prevent fraudulent coins from being easily produced from readily-available metals with an EMS like the new material. The introduction of non-seamless EMS coins would also result in higher conversion costs incurred by the vending industry and other stakeholders to accommodate co-circulation. Those impacts were discussed extensively in Chapter Four of the CTC Final Report.

1.4.2. Alternatives to Production

In addition to the alternative metals, CTC investigated alternatives to the production methods used by the Mint. They found that the Mint's production techniques have been substantially the same for the last 75 years, and, through continuous improvement, remain quite efficient. Although newer processes exist for producing volumes of small parts (such as plastic injection molding), there are no proven ways to more economically produce the quantity and quality of metal stampings such as those produced by the Mint at this time. All other mints in the world use variants of the United States Mint's processes in making their own coins, and the Mint remains the world's largest producer of coined products. With respect to production methods and processes, CTC recommended no major changes to production, and for the Mint to continue to focus on improvement.

As a result, CTC determined that significant production or equipment changes did not need to be considered as part of the proposed action. Instead, they focused on cost-saving changes to the composition of the coins themselves, with any subsequent changes to production dependent on the materials selected (such as eliminating blanking, annealing, washing, and upsetting).

1.4.3. Proposed Action

Based on the testing and research performed in this phase (Phase I) of the Alternative Metals Study, CTC found that there was no more-cost-effective alternative material for the one-cent, and thus recommended that it remain unchanged.

In addressing the seamless[9] alternative options, CTC recommended that the composition of the five-cent be replaced with one of three copper-based options: 669z, G6, or unplated 31157, or a broader material specification that focused on EMS and had broader ranges of compositions to enable more flexibility in sourcing. They also included a recommendation to complete additional testing on 669z-clad C110 copper for use in the dime, quarter-dollar, and half-dollar for seamless transition.

Regarding co-circulation options, CTC found that stainless steel provided a low-cost, silver-white choice for the 5 cent that does not require further treatment for corrosion protection. But while ferritic stainless has a lower material cost, it requires higher striking loads (which can lead to shorter die life) and is ferromagnetic (is attracted to magnets), which is not suitable for most coin-processing sensors. Austenitic stainless is a better candidate as it requires lower striking loads and is not ferromagnetic.

Stainless steel options, however, have lower security, given the relatively cheaper material available. For austenitic stainless steels, their common EMS and conductivity readings do not vary much by grade, and so, are prone to fraud. For ferritic stainless steels, their inconsistent EMS associated with ferritic stainless makes them less secure and the acceptor windows have to be widened to accommodate the variation.

The following tables, 1-3 and 1-4, list the materials identified as potential replacements for all circulating denominations except for the one-cent. CTC recommended that further testing and evaluation be conducted on these materials, which formed the basis for Phase II of the Alternative Metals Study.

[9] In Phase I, "seamless" meant a material with an EMS that matched the current coin's EMS, to allow the new coin to be used in vending machines without changes to the coin acceptor. Diameter and thickness remained unchanged and weight was not a consideration.

Table 1-3. CTC-Recommended Five-Cent Alternatives

Candidate	Composition and Notes
Multi-ply-plated steel	10µm Ni plated on 23µm Cu plated on 4µm Ni plated on low-carbon steel core; provided in planchet form
TPCPZ-plated zinc	3µm Sn plated on 7µm Cu plated on Zn core; provided in planchet form
669z	Cu-10%Zn-5%Ni-10%Mn[10]; lower nickel content than current material; provided in sheet form
G6 mod	Cu-22%Zn-10%Ni-2%Mn; lower nickel content than current material; provided in sheet form
Unplated 31157	Cu-31%Zn-0.5%Ni-6.5%Mn; low-nickel content; provided in planchet form
Stainless steel	Stainless steel; provided in sheet form
Nickel-plated steel	25µm Ni plated on low-carbon steel; provided in planchet form

Sn=tin, Zn=zinc, Mn=manganese

Table 1-4. CTC-Recommended Dime, Quarter-Dollar, and Half-Dollar Alternatives

Candidate	Composition and Notes
Multi-Ply-plated steel	10µm Ni plated on 23µm Cu plated on 4µm Ni plated on low-carbon steel core; provided in planchet form
TPCPZ-plated zinc	5µm Sn plated on 12µm Cu plated on Zn core; provided in planchet form
TPCPZ-plated zinc	7.7µm Sn plated on 12.7µm Cu plated on Zn core; provided in planchet form
TPCPZ-plated zinc	10.2µm Sn plated on 11.2µm Cu plated on Zn core; provided in planchet form
669z-clad C110	Cu-10%Zn-5%Ni-10%Mn cladding; lower nickel content than current cladding; provided in sheet form
G6-mod-clad C110	Cu-22%Zn-10%Ni-2%Mn clad to copper (C110) core; provided in sheet form
Unplated 31157-clad C110	Cu-31%Zn-0.5%Ni-6.5%Mn clad to copper (C110) core; provided in planchet form
302HQ	Stainless steel; glued to copper as “clad” material for limited testing
Nickel-plated steel	25µm Ni plated on low-carbon steel; provided in planchet form

[10] Throughout this report, chemical element percentages are in weight percent; the balance of the composition is the first element listed.

1.5. Phase II

1.5.1. Introduction

In Phase II of the Mint's Alternative Metals Study, the Mint tested five-cent and quarter-dollar alternatives. The dime, quarter-dollar, and half-dollar have an identical composition. The Mint determined that testing of either the dime or the quarter-dollar could be extrapolated to the other (the half-dollar could also be extrapolated), so the Mint only struck quarter-dollar nonsense test pieces in addition to the five-cent pieces in Phase II. The dollar coin was not addressed in Phase II.

The Mint concentrated its efforts on six materials:

- Copper-plated zinc (**CPZ**)
- Multi-ply-plated steel (**MPPS**)
- Nickel-plated steel (**NPS**)
- Stainless steel
- Tin-plated CPZ (**TPCPZ**)
- Cupronickel (**80/20**)[11]

CTC's recommended "potentially seamless" materials (G6 mod, 669z, and 31157) had a distinctly yellow cast to them and did not have significant cost savings, so the Mint rejected those for further consideration. Instead, it chose to pursue a cupronickel alloy similar to that used in the current five-cent, dime, quarter-dollar, and half-dollar (75/25)[12], but with slightly less nickel (80/20), to provide higher cost savings with no discernible color change.

The Mint considered CPZ and monolithic stainless, but only for use in the five-cent. The other compositions were intended for potential use in the five-cent and the quarter-dollar (along with the dime and half-dollar). Out of all the materials tested in Phase II, only the 80/20 alloy was a potentially seamless alternative to the current materials.

1.5.2. Objective

Section 2(a)(1) of Public Law 111-302 authorizes the Secretary of the Treasury to "conduct any appropriate testing of appropriate coinage metallic materials within or outside of the Department of the Treasury." The Mint designed the Alternative Metals Study with several

[11] While the composition is not exactly 80% copper and 20% nickel, this is an approximation and is used as the material's term.

[12] Composition is 75% copper, 25% nickel.

goals in mind. In Phase II of that Study, the Mint's primary goal was to conduct larger scale testing and evaluation of the materials identified in Phase I, using the quantitative measures developed to define the ability of identified alternative material candidates to meet the requirements of coinage production and circulation. Ultimately, the Mint's goal is to compare the performance of alternative material candidates with known characteristics and properties of current coinage materials to determine suitable replacements for those current materials.

1.5.3. Testing

The Mint tested the candidate materials in two groups during Phase II. The first group, the "variability" lots, was a laboratory-produced, limited run intended to identify any shortcomings in the materials and establish the variation expected in EMS before the larger "pre-production" lots were run. The Mint purchased these "variability lots" of the selected material in quantities at the minimum, nominal, and maximum of the supplier's production control band. During the variability testing, the Mint struck 500 pieces, minimum, for each metal; this was not enough to determine die life or modes of failure, but it was more than sufficient to determine wear, steam corrosion, external EMS characteristics, hardness, conductivity, and coin-sorting/verification (CSV)[13] results.

Later, in the pre-production testing, the Mint tested multiple die pairs for each candidate, and ran those either until die failure, or when a die pair reached 500,000 strikes, whichever came first. The purpose of the pre-production stage was to determine the materials' production viability and provide a relative indication of expected die life, not a statistical die-life projection. To estimate actual die life would require many more test runs. The Mint chose 500,000 strikes per die pair—as that is considered a representative die life for the five-cent and quarter-dollar denominations currently minted—and four die pairs, so as to not pose an undue burden from a testing productivity perspective. Extended runs were conducted on the current material with nonsense dies to validate the baseline of 500,000 strikes.

Table 1-5, below, depicts current-material, five-cent, die-life performance in Philadelphia and supports the targeted level of 500,000 strikes as reasonable, although actual performance averages vary.

[13] CSV machines test many variables of coins that pass through their sensors, including ferromagnetism, permeability, EMS, diameter, and thickness. CSVs are common in the vending-machine industry.

Table 1-5. Average Die-Life Performance (Five-Cent) – Philadelphia

	CY2011	CY2012	CY2013	CY2014TD
Obverse	521	435	537	527-704
Reverse	490	577	488	560-755

Die life is shown in thousands of strikes per die.

Table 1-6, below, shows die-life performance for the quarter-dollar in Philadelphia and supports the targeted level of 500,000 strikes as reasonable.

Table 1-6. Average Die-Life Performance (Quarter-Dollar) – Philadelphia

	CY2011	CY2012	CY2013	CY2014TD
Obverse	503	431	640	481
Reverse	497	413	647	470

Die life is shown in thousands of strikes per die.

There is more variability in quarter-dollar die life than in the five-cent's as each year there are five new reverse designs for the America the Beautiful (ATB) series which affects both the reverse and the obverse die life.

1.6. Other Research and Development

In addition to testing and evaluating the metals above, the Mint continued researching and considering additional alternative materials. The Mint performed secondary research with the National Institute of Standards and Technology on another potentially seamless material, C77000, and researched co-circulate alternatives such as zinc-aluminum alloy, silicon steel, and plated steel provided in sheets with an exposed edge. This secondary research was intended to continue the broader search for lower-cost alternatives, and to ensure a more thorough and ongoing approach to the Alternative Metals Study.

C77000

C77000 is a monolithic copper alloy (Cu-27%Zn-18%Ni) that the Mint identified for its lower nickel content compared with the current alloy and for its potentially similar EMS signature, which can make it a seamless candidate. Also known as "nickel silver," C77000 does not exhibit the "yellowing" tendency shown by the other copper-based alloys identified in Phase I, which was another factor in its favor. The Mint will perform more extensive testing on this alloy and on alloys based on it to better characterize its potential.

Plated Steel

The Mint looked at plated steel in sheet form. Steel is much less expensive than any other substrate in Phase II, and the use of plated strip is a more cost-effective coating method than plating planchets. It also has a more uniform layer which would yield more consistent EMS readings. The principal negative is the exposed edge, which would be untreated steel and subject to corrosion.

Silicon Steel

Silicon steel, commonly called "electrical steel," exhibited different electromagnetic signatures from normal or stainless steel during initial testing and the Mint regarded it as a potential alternative to the plain steel core used in the plated materials under consideration (MPPS and NPS). Also, if its corrosion resistance could be improved, it could be considered as a monolithic material in lower-denomination coins.

Zinc-Aluminum

The Mint pursued zinc-aluminum alloys because test pieces made solely of zinc or of aluminum had limitations in Phase I (zinc showed poor corrosion resistance unless coated or plated, and aluminum was very light and presented handling issues), but a combination of the two showed initial promise. However, in testing, the combined material still showed a lack of acceptable corrosion resistance through various metallurgical phases that created areas of acceptable and unacceptable corrosion on the surface. This corrosion tendency could not be controlled with a binary zinc-aluminum alloy.

Nickel-Plated CPZ

The CPZ supplier has recently developed this alternative to its CPZ, and the Mint plans on testing this plated material to see if it will prove to be more durable than the other zinc-based materials.

1.7. Testing Facilities

In 2011, the Mint constructed a highly secure research and development (R&D) facility inside the Philadelphia Mint and isolated from regular circulating production. This facility's security ensures that materials are tested thoroughly on the same type of equipment as that used in production, and then crushed and/or stored under U.S. Mint Police oversight until the materials can be properly (and securely) destroyed and recycled. In this way, test pieces were isolated from normal production material and proper controls were maintained. Later in 2013/2014, the Mint supplemented the production capabilities of the R&D room with a secure diagnostic lab for conducting metallurgical tests and evaluating alternative materials.

1.8. Independent Peer Review

The Mint proactively elected to have an independent, outside authority review the Mint's research methods and processes, testing methods, and data. The Mint subsequently entered into an Interagency Agreement (IA) with the U.S. Department of Energy (DOE), which owns the facilities that house Argonne National Laboratory (Argonne). Under the IA, Argonne was to conduct an independent verification and validation (IV&V) of the Alternative Metals Study, Phase II. In this independent peer review (IPR), Argonne ensured that the Mint's processes, tests, and evaluations were valid and that the findings and conclusions were supportable.

During the course of testing, the Mint provided documentation of all procedures, test data, and analyses to the Argonne IPR team for their input. Argonne responded in timely fashion to all data sent to them over the course of the R&D effort and identified potential gaps and concerns that were satisfactorily answered by the Mint. In every case, Argonne verified and validated the Mint's efforts. In late 2014, Argonne issued their official report. The following page contains its executive summary.

1.8.1. Argonne Report Executive Summary

Argonne National Laboratory provided IV&V services to the US Mint for its Alternative Metals Study – Phase II. Services includes (1) validation of project plans, (2) review testing and evaluation, (3) review down-selection plan, and (4) validation of the US Mint's final recommendations. This report is the final deliverable of IV&V service contract.

Validation of project's plans included an initial on-site visit to the US Mint R&D facilities in Philadelphia. Testing capabilities were reviewed and found to be adequate for performing the planned work. Documentation relating to the experimental work was reviewed and any deficiencies were corrected by the US Mint.

Project performance was reviewed during weekly conference calls, as well as review of US Mint experimental data documentation provided by secure file transfer. Data generated and provided was consistent with expectations. In addition, a second site visit was performed to review and witness on-site testing, including wear testing.

The down-selection plan was reviewed and found to be sound. The testing regimen was sufficient to provide discriminating data amongst the various alternative metal candidates.

The US Mint's final recommendations are documented in its 2014 Biennial Report to Congress. Six alternative metal compositions were evaluated. The findings and recommendations are:

1. Continue the 80/20 alloy testing and evaluation
2. Pursue seamless alloy development
3. Continue stainless steel R&D
4. Explore production improvements

The US Mint also concluded that plated zinc metal alternatives (CPZ and TPCPZ) should be eliminated from further consideration.

IV&V Findings Statement

The US Mint followed established protocols in performing the R&D work. The work plan was sound and addressed the key metal physical and chemical properties. The tests revealed positive and negative aspects of the alternative metals under consideration. The findings, conclusions, and recommendation made by the US Mint are supported by the work performed in this project.

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1.9. Public Law 111-302

Public Law 111–302
111th Congress

An Act

To provide research and development authority for alternative coinage materials to the Secretary of the Treasury, increase congressional oversight over coin production, and ensure the continuity of certain numismatic items.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Coin Modernization, Oversight, and Continuity Act of 2010".

SEC. 2. AUTHORITY TO CONDUCT RESEARCH AND DEVELOPMENT ON ALL CIRCULATING COINS.

(a) IN GENERAL.—To accomplish the goals of this Act and the requirements of subchapter II of chapter 51 of title 31, United States Code, the Secretary of the Treasury may—

(1) conduct any appropriate testing of appropriate coinage metallic materials within or outside of the Department of the Treasury; and

(2) solicit input from or otherwise work in conjunction with entities within or outside of the Federal Government including independent research facilities or current or potential suppliers of the metallic material used in volume production of circulating coins,

to complete the report referred to in this Act and to develop and evaluate the use of new metallic materials.

(b) FACTORS TO BE CONSIDERED.—In the conduct of research, development, and the solicitation of input or work in conjunction with entities within and outside the Federal Government, and in reporting to the Congress with recommendations, as required by this Act, the Secretary of the Treasury shall consider the following:

(1) Factors relevant to the potential impact of any revisions to the composition of the material used in coin production on the current coinage material suppliers.

(2) Factors relevant to the ease of use and ability to cocirculate of new coinage materials, including the effect on vending machines and commercial coin processing equipment and making certain, to the greatest extent practicable, that any new coins work without interruption in existing coin acceptance equipment without modification.

(3) Such other factors that the Secretary of the Treasury, in consultation with merchants who would be affected by any change in the composition of circulating coins, vending machine and other coin acceptor manufacturers, vending machine owners and operators, transit officials, municipal parking officials, depository institutions, coin and currency handlers, armored-car operators, car wash operators, and American-owned manufacturers of commercial coin processing equipment, considers to be appropriate and in the public interest, after notice and opportunity for comment.

SEC. 3. BIENNIAL REPORT TO THE CONGRESS ON THE CURRENT STATUS OF COIN PRODUCTION COSTS AND ANALYSIS OF ALTERNATIVE CONTENT.

(a) REPORT REQUIRED.—Before the end of the 2-year period beginning on the date of the enactment of this Act, and at 2-year intervals following the end of such period, the Secretary of the Treasury shall submit a report to the Committee on Financial Services of the House of Representatives and the Committee on Banking, Housing, and Urban Affairs of the Senate analyzing production costs for each circulating coin, cost trends for such production, and possible new metallic materials or technologies for the production of circulating coins.

(b) DETAILED RECOMMENDATIONS.—In preparing and submitting the reports required under subsection (a), the Secretary of the Treasury shall include detailed recommendations for any appropriate changes to the metallic content of circulating coins in such a form that the recommendations could be enacted into law as appropriate.

(c) IMPROVED PRODUCTION EFFICIENCY.—In preparing and submitting the reports required under subsection (a), the Secretary of the Treasury shall include recommendations for changes in the methods of producing coins that would further reduce the costs to produce circulating coins, and include notes on the legislative changes that are necessary to achieve such goals.

(d) MINIMIZING CONVERSION COSTS.—In preparing and submitting the reports required under subsection (a), the Secretary of the Treasury, to the greatest extent possible, may not include any recommendation for new specifications for producing a circulating coin that would require any significant change to coin-accepting and coin-handling equipment to accommodate changes to all circulating coins simultaneously.

(e) FRAUD PREVENTION.—The reports required under this section shall make no recommendation for a specification change that would facilitate or allow the use of a coin with a lesser value produced, minted, or issued by another country, or the use of any token or other easily or regularly produced metal device of minimal value, in the place of a circulating coin produced by the Secretary.

(f) RULE OF CONSTRUCTION.—No provision of this Act shall be construed as requiring that additional research and development be conducted for any report under this Act but any such report shall include information on any such research and development during the period covered by the report.

SEC. 4. MEETING DEMAND FOR SILVER AND GOLD NUMISMATIC ITEMS.

Subsections (e) and (i) of section 5112 of title 31, United States Code are each amended by striking "quantities" and inserting "qualities and quantities that the Secretary determines are".

SEC. 5. TECHNICAL CORRECTIONS.

Section 5112(u)(1) of title 31, United States Code is amended—

(1) by striking "exact duplicates" and inserting "likenesses";

(2) by striking subparagraph (C);

(3) by redesignating subparagraphs (D) and (E) as subparagraphs (C) and (D), respectively; and

(4) in subparagraph (A), by striking "of 3.0 inches" and inserting "determined by the Secretary that is no less than 2.5 inches and no greater than 3.0 inches".

SEC. 6. BUDGETARY EFFECT.

The budgetary effects of this Act, for the purpose of complying with the Statutory Pay-As-You-Go Act of 2010, shall be determined by reference to the latest statement titled "Budgetary Effects of PAYGO Legislation" for this Act, submitted for printing in the Congressional Record by the Chairman of the House Budget Committee, provided that such statement has been submitted prior to the vote on passage.

Approved December 14, 2010.

2. Materials

2.1. Introduction

Several alloys the Mint chose to research in Phase II include similar metals. Those metals are nickel, copper, zinc, and steel. Other metals are present in some alloys (such as manganese, aluminum or tin), but in smaller percentages.

2.1.1. Raw Metals

The following are price histories and basic facts on the major raw metals that were a part of Phase II of this study, from most expensive to least.

Nickel

Figure 2-1. Commodity Price History of Nickel, 1999 to 2014[14]

The Mint began using nickel in its coins in 1857, and in 1866, the five-cent gained its 25 percent nickel composition/appearance and its popular moniker, the "nickel." Its silver-white color has made it a popular metal for coining since the 19th century, but its rising price has made many countries replace it with less-expensive iron (steel) alloys in recent years.

[14] USGS information was only available through 2010, so was not used in this section.

Nickel's price of just under $7/lb as of January 2014 was barely one-third that of its peak in 2007 and was about the same as it briefly was in 2004. However, its price in January 2014 was still over three times higher than it was in 1999, and it has seen fluctuations over the last five years that pushed it as high as six times the 1999 price. The five-cent has borne the brunt of this rising price as there is more nickel in that coin (1.20g) than in any other U.S. coin (0.944g in the half-dollar, 0.472g in the quarter-dollar, 0.189g in the dime), because of its construction and size.

Copper

Figure 2-2. Commodity Price History of Copper, 1999 to 2014

Copper has been in use in U.S. coins since the Mint was founded. It is also the most conductive non-precious metal, and is used in electrical, plumbing, and food-service industries, in addition to coining.

Copper's price saw a similar percentage increase up to 2007 as most other metals did, but it started earlier, and had more fluctuations. Copper is quickly rising in industrial use worldwide, and as a result, its price rebounded after the drop in 2008, increasing back to or above its 2007 levels. Copper's price is still relatively low in spite of the percentage increase, barely above $3/lb at the start of 2014. The quarter-dollar contains more copper (5.198g) than any other U.S. coin produced for circulation (3.75g in the five-cent, 2.079g in the dime). Two-thirds of the quarter-dollar's construction is its pure-copper core, and its cladding is 75 percent copper.

Manganese

Manganese is the ninth-most-abundant metal on Earth, and is used mainly in steel production. It has been used in American coins as far back as 1942, when it and silver were added to the five-cent to replace the nickel content and some of the copper content during World War II. It has also been used in the dollar coin since 2000.

Manganese is not traded on the commodities market, but pricing history from 2005 to present is available. This pricing history is based on weekly average sales prices that are averaged out from the multiple companies that have reported their sales figures.

The price of manganese increased to a high of more than $2.30/lb in 2007. In 2008, the price fell to $1.42/lb. Prices fell further in 2009 to $1/lb., and while they have fluctuated over the past five years, at the start of 2014, prices were just over $1/lb.

Zinc

Figure 2-3. Commodity Price History of Zinc, 1999 to 2014

Zinc is the fourth-most-common metal in use (behind iron, aluminum, and copper), and world resources are estimated at 1.9 billion tonnes, with major deposits and several mines in the United States.

Its price graph is quite similar to that of nickel, but at a far smaller scale (nickel reached a peak price over $23/lb vs. barely over $2/lb for zinc). The percentage changes in both zinc

and nickel over the last 15 years, however, are remarkably similar. As of January 2014, zinc was trading at just over $0.90/lb.

In spite of increasing demand for zinc, its price has remained relatively stable over the last three years, thanks in large part to increasing production levels, worldwide.

Aluminum

Figure 2-4. Commodity Price History of Aluminum, 1999 to 2014

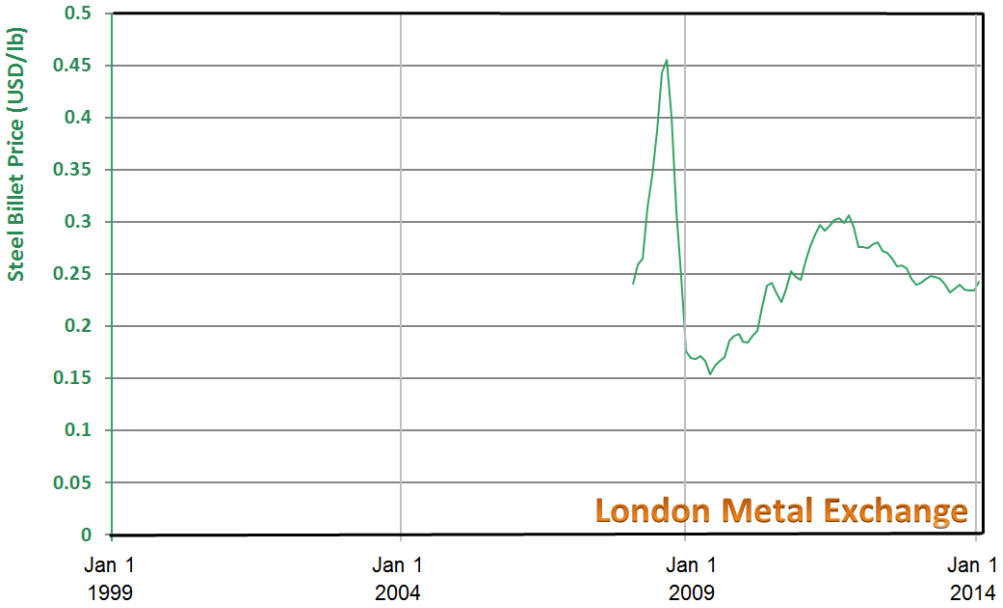
Aluminum is the second-most-abundant metallic element on Earth. Found primarily in the form of bauxite, aluminum is cheaply extracted through the Hall-Héroult Process invented in 1886.

Its price more than doubled between 1999 and 2007, reaching nearly $1.40/lb just before the drop in 2008 took it to $0.60/lb. Prices recovered, peaking at about $1.25/lb in 2011, but as of the start of 2014, its price was just under $0.80/lb.

Aluminum is still in high demand in multiple industries, so its price remains somewhat higher than less-abundant materials, such as steel.

Steel

Figure 2-5. Commodity Price History of Steel Billet, 2008 to 2014



Steel was not openly traded before 2008

Technically an alloy rather than a raw metal, steel is iron mixed with 0.002% to 2.1% carbon. Stainless steel adds more materials for corrosion resistance (including chromium and nickel), and can be ferritic (4XX series, which is drawn to magnets) or austenitic (3XX and 2XX series, not drawn to magnets).

Steel began trading on the London Metal Exchange in 2008 at just under $0.25/lb. After a brief surge in its price to an all-time high of over $0.45/lb, prices fell in 2008 until they hit their low of slightly more than $0.15/lb in May 2009. In the five years since, its price has recovered, but decreasing demand has kept its price relatively low; it was still just over $0.24/lb at the start of 2014.

These are commodity prices for common grades of steel and are provided for illustrating price trends; the steel used in plated-coin materials is a cold-rolled, low-carbon grade and is higher in actual cost than "mild" steel. Stainless steel, with its additional alloying elements, is higher yet in cost per pound.

The supply of each of the raw metals seen in Phase II is both stable and of sufficient supply sources to warrant consideration as use in replacement candidates for current coins.

2.1.2. Other Considerations

Security and fraud prevention play a key role in this study; medium- to high-denomination[15] coins made of inexpensive, easily-accessed metals (or those that also make up washers and other, cheap, coin-sized items) are at a high security risk, as "slugs" can pass for those coins in automated transactions. Plating such coins may not provide enough security from slugging or counterfeiting, as plating facilities, methods, and equipment are plentiful and relatively inexpensive.

Lastly, in reporting to Congress with recommendations on alternative metals, CMOCA requires the Secretary of the Treasury to consider as a factor that, to the greatest extent practicable, any new coins work without interruption in existing coin acceptance equipment without modification, and, to the greatest extent possible, include no recommendation for new specifications for producing circulating coins that would require any significant change to coin-accepting and coin-handling equipment to accommodate changes to all circulating coins simultaneously (Public Law 111-302, Sections 2(b)(2) and 3(d)).

No single (or elemental) metal known, however, can provide a truly seamless interaction with current coins and still provide cost savings. As a result, alloys, plated metals, and clad configurations were the best approach to cost savings while still ensuring a smooth transition.

The candidate materials' density (and therefore the individual piece weight) often varied from the current material, and were usually lighter as heavier alternatives tended to be more costly. The weight variance was difficult to avoid, because in Phase I, CTC recommended the Mint maintain the current physical dimensions (the same diameter and edge thickness), as changing those created a significant impact on shareholders.

CTC further estimated that the costs associated with piece weight changes would be associated predominantly with armored car carriers and bulk coin processors. A weight change would not eliminate a material from technical consideration, but if the candidate material's weight varied too much from the current coin weight, the material would be considered a "co-circulate" option, and not a "seamless" one.

[15] According to the European Vending Association's Handbook (used by mints worldwide as the reference for coins and coin security), "medium" value is approximately 27-68 cents and "high" value is above 68 cents. (See Section 4.)

The Mint chose the Phase II candidate alloys and metals with these considerations in mind, along with availability, sources of proprietary alloys, and key features of the materials, including the material's color and expected durability and recyclability.

2.2. Approach

For all materials in Phase II, the Mint purchased a "variability" lot, and then for all materials except TPCPZ, CPZ, and an 80/20 cupronickel alloy[16], the Mint purchased a "pre-production" lot. Variability lots were lab-produced and small, usually about 500–2,000 pieces of the material. The intent was to provide material that was suitable for characterizing key attributes such as coining, wear, electromagnetic signature (EMS), and corrosion resistance, and to establish the expected composition variation to better characterize the EMS of each alternative material. The pre-production lots were mass-produced and representative of the properties and characteristics that would be seen in actual Mint coining. The Mint processed upwards of approximately 2 million pieces for the material/denomination combinations.

Figure 2-6. Quarter-Dollar Nonsense Test Pieces

For the variability lots, the Mint asked suppliers to give a range of production for the materials' construction. In the case of plated metals, for example, the variability was on the minimum, nominal, and maximum levels of plating. This provided the Mint an understanding of the variability in the materials and allowed the Mint to test alternative materials before spending more money on them. In some cases, materials were rejected from further testing during the variability lot steps (see below).

[16] Optimization of this composition is still on-going with one of the suppliers.

The Mint ran the pre-production lots through the same evaluation tests to which the metals were subjected in the variability lots, but with added tests on die life and planchet dimensions. (The short runs in the variability lots were sufficient to determine proper die-striking force, and to get an indication of die wear, but were too small to test actual die life, or to get a true indication of planchet-size variances.)

The tests run during pre-production testing also gave the Mint a larger, more representative sample of material results than in the variability lots, enabling an assessment of the potential supply chain. With a broader range of test results, more accurate analysis was possible, and the Mint gained a deeper understanding of the feasibility of candidate materials.

Table 2-1. Phase II Test Program Summary

ALTERNATIVE METAL TEST AND EVALUATION STATUS

Material			Variability Lots				Pre-Production Lots					Updated as of July 21, 2014
Potentially Seamless			Mat'l Rec'd	Test Strikes	Wear Test	EMS Test	Mat'l Ordered	Mat'l Due	Pre-Prod Strikes	Wear Test	EMS Test Local	Used by other countries
80/20	A 5¢	Mn 0.2-0.6%		Jun 2013	Passed	Failed	Canceled - failed EMS Test					Yes – US 75/25, Canada 75/25, UK 84/16
	B 5¢	Mn approx 3.0%		Nov 2013	Passed	Complete	Yes	Jun 2014	Jul 2014	Complete	Complete	
			Wear and EMS test on pilot material									
Co-Circulate												
Copper-Plated Zinc (CPZ) 5¢			May 2013	Jun 2013	Failed	Complete	Yes	Rec'd	Jan 2014	Failed	Complete	Yes – US 1¢, Singapore
			Canceled - failed wear test									
Tin-Plated CPZ 5¢ and 25¢			May 2013	Jun 2013	Failed	Complete	Canceled - failed wear test					No
Nickel-Plated Steel 5¢ and 25¢			Jun 2013	Jul 2013	5¢ Passed	Complete	Yes	Jun 2014	Jun 2014	Complete	Complete	Yes – UK, China, and a number of commonwealth countries
					25¢ Passed			Jun 2014	Jul 2014	Complete	Complete	
Multi-Ply-Plated Steel 5¢ and 25¢			Oct 2013	Oct 2013	5¢ Passed	Complete	Yes	Apr 2014	May 2014	Complete	Complete	Yes – Canada and a number of other countries
					25¢ Passed			Apr 2014	May 2014	Complete	Complete	
			Status									
Stainless Monolithic 5¢			CTC Stainless Feasibility Study final report received July 2014. Ten compositions tested, two identified for further testing.									Yes - Mexico, India and several smaller countries

2.3. Key Features

2.3.1. EMS

The electromagnetic signature (EMS) of a coin is extremely important. Most coin-accepting machines use the coin's EMS to verify the coin's value and accept or reject coins on this basis. The security of a unique EMS serves to prevent nearly-worthless discs of cheap metal (slugs) from being passed off as genuine coins in these machines. It also prevents counterfeiters from manufacturing their own coins from cheaper materials.

Plating provides some security and yields an EMS that is more difficult to match with common metals, but plating can be easily replicated.

Cladding[17], on the other hand, can provide a coin with an EMS that is more difficult to match inexpensively, and is not easily copied, effectively deterring counterfeiting and fraud.

2.3.2. Weight

The new coins should weigh as close as possible to the weight of current coins, as some commercial stakeholders rely on weight to facilitate commerce. Currently, there is a +/- 2.1–3.2 percent variance seen[18] in U.S. coinage. This variation is accepted by coin handlers and armored car companies as it is very minor and goes both up and down, so it tends to balance out, overall. The Mint considers matching-EMS candidate materials with weight that falls within this variance to be seamless.

Historically, the dime, quarter-dollar, and half-dollar have shared a direct relation between their values and their weights. The quarter-dollar (2.5 times the value of the dime) weighs precisely 2.5 times the weight of the dime (5.670g v. 2.268g) and the half-dollar (2.0 times the value of the quarter-dollar) weighs exactly 2.0 times the weight of the quarter-dollar (11.340g v. 5.670g). As a result, carriers have been able to bag dimes and quarters together and accurately estimate their value very quickly.

If there is only a minor difference in piece weight between a candidate material and the current material, it could be accepted as the present variation is, or the Mint could mitigate it by making small changes in the features of the coin, and the Mint kept this in mind as testing proceeded.

According to CTC's report from Phase I, a change in piece weight carried a lower cost to coin stakeholders than did a change to either the EMS or ferromagnetism of the current coin (given that dimensions of diameter and thickness need to remain the same), but it is a per-year cost.

2.3.3. Color

Since the 19th century, the five-cent, dime, and quarter-dollar have had a silver-white appearance. When these coins were changed to their current cupronickel composition in 1965, color was a factor in the material chosen, to allay any public concerns about the new coins.

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[17] Cladding is defined in Section 2.3.4.

[18] Actual figures from Philadelphia Mint production from June 2013 to June 2014.

CPZ was the only metal examined in the primary testing and evaluation of Phase II that is not gray- or silver-white, and was considered solely for the five-cent based on potential cost savings. Several alternative metal candidates in Phase I were rejected from Phase II because they were too yellow.

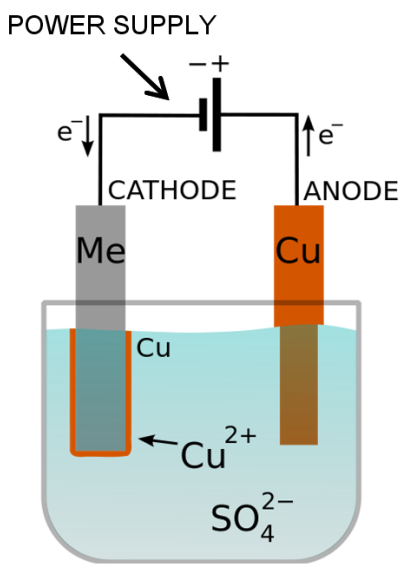
2.3.4. Construction

In Phase II, the Mint examined alternative metals in three basic composition types: plated, monolithic, and clad. No material tested in this phase was a simple elemental metal.

Plating

Plated metals have a metal core plated with one or more other metals in thin layers. The reason for this plating can be for color, security, EMS, corrosion/wear protection, or a combination thereof. Plating is performed in many ways, with multiple variations, but only electroplating was seen in plated candidate metals of Phase II.

Figure 2-7. Electroplating



"Me" in this figure is a stand-in for any metal.

Electroplating uses an electric current to move metal from an anode (such as copper) in an electrolytic solution onto a metal cathode (for example, zinc discs) in the solution. As shown in Figure 2-7, when the anode is positively charged, its metal atoms are oxidized, creating metal ions (Cu^{2+}) that dissolve in the electrolytic solution. At the negatively-charged cathode, the dissolved metal ions in the electrolytic solution are reduced to elemental metal

(Cu) at the solution/cathode interface. The cathode is sometimes referred to as a "core" or "substrate."

Plating thickness varies over the surface of the piece with heavier thicknesses on the edge, as a function of the plating physics. This variation in plating thickness contributes to a varying ("wider") EMS on plated coins. When plating thicknesses are given, they refer to a measurement in the center of the plated piece.

Monolithic

A monolithic alloy is a homogeneous (evenly mixed) blend of a metal and at least one other material. This is different from plating or cladding in that there are no layers; the materials are melted down and mixed together into a single alloy that is the same, through and through.

Cladding

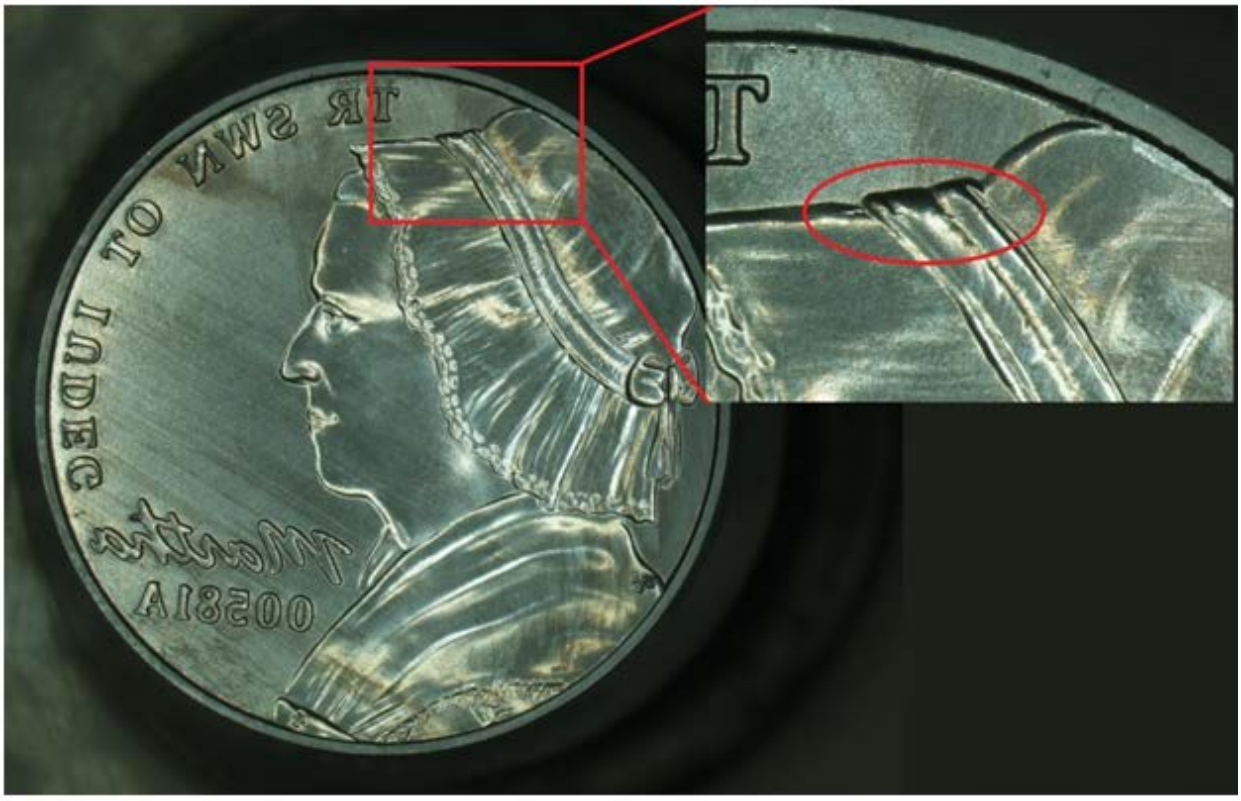
Clad metals can use either, both, or none of the above constructions. Cladding bonds dissimilar metals together. The clad material could then be plated, but this is not usually done in coining.

Typically, clad coinage metals are "roll clad," a process in which the layers of metal (for coins, this is usually a symmetrical "sandwich" of an odd number of layers) are thoroughly cleaned and passed through a series of rollers under sufficient mechanical pressure to bond the layers together. The high force serves to permanently deform the metals and to reduce their combined thickness in the process.

2.3.5. Hardness

Rockwell 15T hardness tests determine a material's hardness relative to other materials. Planchets made from harder materials will typically require more force to strike or form a coin. More force to strike can also mean more stress-induced cracking and chipping on the die (tooling) surfaces, which creates defects on the resultant coin and can shorten the die's life.

Figure 2-8. Damaged Die



Die 00581A (obverse), with a hairline crack at the top of Martha Washington's bonnet.

A material that is too soft, however, can excessively deform when it is blanked (cupping)[19] or upset. Beyond the impact to production, coins made of material that is too soft can cause significant damage to automatic coin handling/processing equipment (for example, if the coins can cold-weld together or if they fail to convey through coin acceptors). They may also not stand up to the wear a coin experiences in normal circulation, and can rapidly become too damaged to circulate.

Another consideration with regards to hardness is a material's ductility and tensile strength. A ductile material "flows" in the striking process, allowing it to more easily fill in the peaks and valleys in the die's design.

While a material that shattered upon striking would have been eliminated from consideration, no such conditions existed in Phase II, and hardness itself was not a basis in

[19] See attached Laser-Blanking Study for section on "push-back blanking" as a counter to cupping.

determining a material's feasibility. Ductility was, however, indirectly a factor, as it affected how well a material achieved proper detail ("filled") on strikes during progression strikes (the first step in testing). As a result, the Mint considered hardness as a property to test, but not as a precursor to success in coining a material.

2.4. The Materials

Following are the current material used in U.S. coins, and the six candidate materials from Phase II. These entries show only the five-cent and the quarter-dollar, as the quarter-dollar served as the proxy for the three clad denominations (dime, quarter-dollar, and half-dollar which use the same composition of material, just rolled to different thicknesses) for this study.

2.4.1. Current

The Mint performed identical tests on the current material and the alternative candidates.

Table 2-3. Current Material Specifications

Coin	Material	Construction	Weight
Five-Cent	Cu-25%Ni (cupronickel)	Monolithic	5.000g
Quarter-Dollar	Cupronickel clad to copper core	Clad (cupronickel over C110 copper)	5.670g

2.4.2. 80/20 Cupronickel

The 80/20 candidate is very similar to the current 75/25 material, with 20 percent less nickel in its composition. In the five-cent, this is a significant change, though for the quarter-dollar, it only comes to 20 percent of 8.33 percent, or only 1.67 percent of the coin's overall makeup. As a result, while 80/20 is a seamless alternative, cost savings with that material are small compared with other alternatives.

The two "80/20" material samples were ordered in two different compositions; 80/20A was Cu/20%Ni with a minor amount of manganese (which tested as having an EMS too different from the current material), while 80/20B contained more manganese, replacing some of the copper and nickel, for a final composition of Cu-19.7%Ni-3.3%Mn.

Table 2-4. 80/20B Specifications

Coin	Material	Construction	Weight
Five-Cent	Cu-20%Ni-3%Mn	Monolithic (cupronickel)	4.96g

2.4.3. Copper-Plated Zinc (CPZ)

The planchets used in the current U.S. one-cent are zinc discs plated with 8μm of copper, known as copper-plated zinc, or CPZ. The Mint examined this material as a potential alternative for the five-cent, but after it failed the variability lot wear test, it was dropped from consideration.

Table 2-5. CPZ Specifications

Coin	Material	Construction	Weight
Five-Cent	8μm Cu plated on Zn-.8%Cu core	Zinc plated with copper	4.06g

2.4.4. Multi-Ply-Plated Steel

Multi-Ply-Plated Steel (MPPS) is a process developed and patented by the Royal Canadian Mint (RCM) in which RCM takes a core of cold-rolled, low-carbon steel and first plates it with nickel, then copper, and then nickel again. MPPS is used in over 60 countries; Canada supplies approximately half of those countries with MPPS, and the other half manufacture it under license.

The multiple layers of plating allow RCM to alter the EMS of the coin by changing the thickness of the plating layers. The Mint struck this candidate in five-cent and quarter-dollar nonsense pieces.

MPPS has significant vulnerabilities to fraud and counterfeiting, and is used in lower-value world coins that are a similar size as the quarter-dollar, and is therefore not feasible for use in the quarter-dollar. It is, however, feasible for use in the five-cent and potentially in the dime.

Table 2-6. MPPS Specifications

Coin	Material	Construction	Weight
Five-Cent	4µm Ni on 5µm Cu on 10µm Ni on Steel core	Plated (nickel-copper-nickel over steel)	4.37g
Quarter-Dollar	4µm Ni on 23µm Cu on 10µm Ni on Steel core	Plated (nickel-copper-nickel over steel)	5.03g

2.4.5. Nickel-Plated Steel

Nickel-plated steel (NPS) can be legally manufactured by anyone with the means to plate nickel on steel. Currently, it is used on coins in the UK and a number of other countries around the world (in 2013, the RM produced 2.29 billion NPS coins and blanks for 38 customers). NPS is made from cold-rolled, low-carbon steel planchets plated nominally with 25µm of nickel, which is thick enough to generate a clearly discernable EMS, though it is a different EMS from current U.S. coins. The Mint struck this candidate in five-cent and quarter-dollar nonsense pieces.

NPS has significant vulnerabilities to fraud and counterfeiting, and is used in lower-value world coins that are a similar size as the quarter-dollar, and is therefore not feasible for use in the quarter-dollar. It is, however, feasible for use in the five-cent and potentially in the dime.

Table 2-7. NPS Specifications

Coin	Material	Construction	Weight
Five-Cent	25µm Ni plated on Steel core	Plated (nickel over steel)	4.40g
Quarter-Dollar	25µm Ni plated on Steel core	Plated (nickel over steel)	5.03g

2.4.6. Stainless Steel

Stainless steel is more expensive than carbon steels, but it does not need surface treatment for corrosion protection and is still priced lower than most other metals and alloys. By definition, stainless steel contains more than 12 percent chromium, though it can contain other elements—most notably, nickel.

Ferritic (i.e., drawn to magnets) stainless steel has relatively low or no nickel content, which makes it a low-cost option over austenitic (i.e., not drawn to magnets) stainless that contains significant quantities of nickel.

The makeup of stainless steel, while imparting the desired corrosion resistance, also makes the material more difficult to strike. The focus of CTC's study was to identify a composition and thermal mechanical practice[20] that provided the desired balance between the two.

The Mint, working with CTC, evaluated this easily counterfeited material solely for the low-denomination five-cent.

Table 2-8. Stainless Steel Specifications

Coin	Material	Construction	Weight
Five-Cent	Fe-C-Mn-Si-Ni-Cr	Monolithic Stainless Steel	4.37g

2.4.7. Tin-Plated Copper-Plated Zinc (TPCPZ)

TPCPZ is a copper-plated zinc planchet that is further plated in tin for the silver-white color the public expects on the five-cent, dime, and quarter-dollar. The Mint struck this candidate in five-cent and quarter-dollar nonsense pieces. TPCPZ failed the wear test, and the Mint eliminated it from further consideration.

Table 2-9. TPCPZ Specifications

Coin	Material	Construction	Weight
Five-Cent	Zn-Cu-Sn	Sn plated on Cu plated on Zn	4.1g
Quarter-Dollar	Zn-Cu-Sn	Sn plated on Cu plated on Zn	4.54g

2.5. Cost

As has been stated, the driving factor behind Public Law 111-302 was lowering the cost of U.S. coins. Production, fabrication, and metal costs all add up, but recycling options have also been a factor, including web scrap recycling options, in the case of material sent to the

[20] Thermal mechanical practice refers to the cold-rolling reduction and annealing practices which control the mechanical properties of the material.

Mint as coiled roll. The cost of minting coins is defrayed when old coins and condemned material are directly recycled by the supplier into new material for coins. When this is not an option, however, the Mint can still see some returns if there is another recycler interested in buying the scrap metal or if the supplier has other uses for the metal. This recycling then introduces another security factor (ensuring the coins are melted down by the recycler) and generally gains the Mint less money than if the material can be returned directly to the coin material supplier and reused as stock for future coin material.

Stainless steel, CPZ, and 80/20 have direct recycling options with the coin material supplier. These are figured into the metal costs of these materials, shown in Tables 2-10 and 2-11, below. The cost breakdown includes estimations of fabrication costs in some cases, as the actual numbers were not supplied.

Table 2-10. Estimated Unit Costs of Five-Cent Candidates

Candidate Material	Metal Cost	Supplier Fabrication	U.S. Mint Direct Production	Metal +Fabrication +Production	Overhead +G&A +Distribution	Est. TOTAL
Current (FY2014)	4.21	0.76	0.42	**5.39**	**2.48**	**7.87**
80/20 Cupronickel	3.88	0.76	0.42	**5.07**	**2.48**	**7.54**
3XX Stainless Steel	2.11	0.76	0.49	**3.35**	**2.48**	**5.83**
Multi-Ply Plated Steel		2.81	0.21	**3.02**	**2.48**	**5.50**
Nickel-Plated Steel		3.42	0.21	**3.63**	**2.48**	**6.11**
Copper-Plated Zinc		1.70	0.21	**1.91**	**2.48**	**4.39**
Tin-Plated CPZ		1.97	0.21	**2.18**	**2.48**	**4.66**

Green indicates a "seamless" alternative and red, a canceled alternative. All costs are in cents.
Plated materials' Metal Cost and Supplier Fabrication are supplier quotes from October 2013.
All other figures are from FY2014 (YTD through March 2014).

Table 2-11. Estimated Unit Costs of Quarter-Dollar Candidates

Candidate Material	Metal Cost	Supplier Fabrication	U.S. Mint Direct Production	Metal +Fabrication +Production	Overhead +G&A +Distribution	Est. TOTAL
Current (FY2014)	4.08	1.75	0.48	**6.31**	**2.81**	**9.12**
80/20 Cupronickel	3.88	1.75	0.48	**6.19**	**2.81**	**9.00**
Multi-Ply Plated Steel	3.46		0.24	**3.70**	**2.81**	**6.51**
Nickel-Plated Steel	3.71		0.24	**3.95**	**2.81**	**6.76**
Tin-Plated CPZ	3.79		0.24	**4.03**	**2.81**	**6.84**

Green indicates a "seamless" alternative and red, a canceled alternative. All costs are in cents.
Plated materials' Metal Cost and Supplier Fabrication are supplier quotes from October 2013.
All other figures are from FY2014 (YTD through March 2014).

Table 2-12, below, shows the cost breakdown of the current coins and their alternatives with estimated savings.

Table 2-12. Estimated Cost Breakdown – Current and Alternative Metals

5¢	Annualized Volume	Weight (grams)	Metal Cost	Metal + Supplier Fab + USM Direct Production	USM O/H+ G&A + Distribution	Total Unit Cost	% Savings	Savings Compared to YTD FY-14 5¢ through March 2014 984 M Coins	Notes
FY13 5¢ 1,123 M Coins		5.00	$0.0530	$ 0.0662	$ 0.0279	$ 0.0941		$ -	a
FY14 5¢ (75-25) -->3/31/14 492M coins	984 M	5.00	$0.0421	$ 0.0539	$ 0.0248	$ 0.0787	-16.4%	$ 15,189,203	b
80-20Cu-Ni Solid		4.96	$0.0388	$ 0.0507	$ 0.0248	$ 0.0754	-4.1%	$ 3,211,103	e
Multi-Ply plated steel (p)		4.37	$0.0281	$ 0.0302	$ 0.0248	$ 0.0550	-30.1%	$ 23,335,468	q
3XX Stainless steel (s)		4.46	$0.0211	$ 0.0335	$ 0.0248	$ 0.0583	-25.9%	$ 20,097,771	e
Nickel plated steel (p)		4.40	$0.0342	$ 0.0363	$ 0.0248	$ 0.0611	-22.3%	$ 17,310,451	q
CPZ (p) 8 µm		4.06	$0.0094	$ 0.0191	$ 0.0248	$ 0.0439	-44.2%	$ 34,254,534	q
Tin plated CPZ (p)		4.10	$0.0197	$ 0.0218	$ 0.0248	$ 0.0466	-40.8%	$ 31,614,856	q
10¢	**Annual Volume**	**Weight (grams)**	**Metal Cost**	**Metal + Supplier Fab + USM Direct Production**	**USM O/H+ G&A + Distribution**	**Total Unit Cost**	**% Savings**	**Savings Compared to YTD FY-14 10¢ through March 2014 1,650 M Coins**	
FY13 10¢		2.27	$0.0204	$ 0.0307	$ 0.0149	$ 0.0456		$ -	a
FY14 10¢ (92-8) -->3/31/14 825M coins	1,650 M		$0.0169	$ 0.0267	$ 0.0140	$ 0.0407	-10.7%	$ 8,027,772	b
80-20 Cu-Ni Clad		2.27	$0.0165	$ 0.0262	$ 0.0140	$ 0.0403	-1.2%	$ 791,839	e
Multi-Ply plated steel (p)		2.00	$0.0217	$ 0.0231	$ 0.0140	$ 0.0371	-8.9%	$ 5,956,892	e
Nickel plated steel (p)		2.00	$0.0225	$ 0.0238	$ 0.0140	$ 0.0379	-7.0%	$ 4,735,956	e
25¢	**Annual Volume**	**Weight (grams)**	**Metal Cost**	**Metal + Supplier Fab + USM Direct Production**	**USM O/H+ G&A + Distribution**	**Total Unit Cost**	**% Savings**	**Savings Compared to YTD FY-14 25¢ through March 2014 1,062 M Coins**	**Notes**
FY13 25¢ 1,062 M Coins		5.67	$0.0465	$ 0.0714	$ 0.0336	$ 0.1050		$ -	a
FY14 25¢ (92-8) -->3/31/14 592.2M coins	1,062 M	5.67	$0.0408	$ 0.0631	$ 0.0281	$ 0.0912	-13.2%	$ 14,715,198	b
80-20 Cu-Ni Clad		5.66	$0.0396	$ 0.0619	$ 0.0281	$ 0.0900	-1.3%	$ 1,252,998	e
Multi-Ply plated steel (p)		5.03	$0.0346	$ 0.0370	$ 0.0281	$ 0.0651	-28.6%	$ 27,718,074	q
Nickel plated steel (p)		5.03	$0.0371	$ 0.0395	$ 0.0281	$ 0.0676	-25.8%	$ 25,020,594	q
Tin plated CPZ (p)		4.54	$0.0379	$ 0.0403	$ 0.0281	$ 0.0684	-25.0%	$ 24,171,079	q

Notes:
a = FY13 Actuals
b = FY2014 10/1/13–3/31/14
e = Estimate
q = Supplier quote

Key:
(cs)=clad strip
(p)=plated
(s)=strip
Green=seamless alternative and Red=cancelled alternative

Assumptions:
> FY13 unit cost data is from FY13 Annual Report
> Mint Production, G&A, and distribution costs are FY14 YTD through March
> Volumes are annualized FY14 (YTD through March) volumes.
> Savings are calculated based on FY14 YTD through March total unit costs and volumes

2.6. Sourcing

The Mint requires a consistent supply of metal for its coins and medals. Successful candidate materials must therefore be made of metals that are readily available and in good supply. This was evident when the U.S. Treasury saw its silver reserves drop to dangerously low levels in the early 1960s.

Competition among suppliers can help the Mint keep costs down if the Mint uses materials with multiple suppliers over those with a single, proprietary supplier. The availability and ease of sourcing, though, must be balanced with concerns over broad access and security.

Currently, the Mint orders its materials from domestic suppliers. Suppliers get the best quality metal at the best prices, which often means foreign sources. Those foreign sources usually have friendly relations with the U.S., but domestic suppliers are preferable, not only for the lower risk, but also for lower shipping costs and a shorter supply chain.

Cupronickel (80/20)

The two cupronickel suppliers for Phase II obtain their nickel and copper from many of the same sources globally. These foreign and domestic sources have been consistent, and more sources, including a potential domestic nickel source, are appearing.

Copper-Plated Zinc and TPCPZ

The CPZ supplier obtains its zinc primarily from Canada, but also through recycling. Its copper and tin come from domestic and foreign sources, depending on price levels and availability, and also from recycling.

Multi-Ply-Plated Steel

The Mint bought this material from the Royal Canadian Mint, which patented and manufactures this material for their own and other nations' coins.

Nickel-Plated Steel

The Royal Mint obtains their nickel and steel from sources in Wales (UK) and supplied this material to the Mint for Phase II.

Stainless Steel

The suppliers obtain their raw materials from multiple sources, both domestic and foreign, and in major part from recycling. Depending on which grade would be selected, there may be sourcing limitations posed by intellectual property rights.

3. Testing

The Mint purchased the candidate materials first in small variability lots, typically 500 to 2,000 pieces produced in a lab environment spanning the expected range of composition/ construction anticipated in normal production processes, and tested each for the feasibility of their use as U.S. coins. After evaluation and passing a "Go/No-Go" determination, materials were tested in pre-production lots, typically 2 million pieces, for a final determination.

Stainless steel, however, was not run through variability or pre-production, though CTC and the Mint tested and evaluated various, preliminary grades until two were recommended (see the attached Stainless Feasibility Study; the Executive Summary is in Section 8). Future testing on the two, identified, stainless-steel materials would conform to the control plan for variability lots, and—if justified—pre-production testing.

In all cases, these materials were struck as "nonsense" pieces that, at first glance, looked like U.S. coins with accurate dimensions, but with Martha Washington's profile on the obverse and had the letters in all the words (like "Liberty" or "United States of America") scrambled. After testing, nonsense pieces that were no longer required were crushed and either sent back to the supplier (current baseline pieces), or securely melted (alternative metal pieces).

3.1. Control Plan and Procedures

3.1.1. Control Plan

Before testing in Phase II began, the Mint prepared a plan by which testing would progress. The Control Plan detailed each step in testing, the criteria "Go/No-Go," and the assumptions, risks, and roles and responsibilities. By creating a detailed plan, the Mint prepared a guide by which Argonne National Lab (Argonne) could follow the Mint's progress easily for its Independent Peer Review (IPR) (see Section 1.8).

3.1.2. Procedures

To ensure consistent test results, the Mint established quality assurance Standard Operating Procedures (SOPs) for each step in the testing. These SOPs established test objectives and clearly defined, possible-result parameters. Each SOP established what kind of instrument would be used, how long the test would last, how many pieces would be tested, and what (if any) criteria there would be for Go/No-Go or for down selection. Throughout Phase II, the Mint followed the SOPs, documented their progress, and provided copies of the progress documentation and the SOPs to Argonne for its IPR.

3.2. Steps

3.2.1. Progression Strikes

Each material needed to first go through "progression" strikes. The Mint first struck five planchets of the material at a low tonnage (press force) and then examined the struck pieces for dimensions and for image detail. The Mint then struck five more planchets at each progressively higher tonnage, and continued to examine the dimensions and detail until it was determined to be sufficient for a U.S. circulating coin. At each step in this process, for each metal, the Mint recorded the tonnage, dimensions, and the level of detail.

Figure 3-1. R&D Coining Press

The horizontal press at the testing facilities.

When the correct level of detail was reached, or when the maximum tonnage for that material was reached, the rest of the material was struck at that tonnage for that stage of testing.

Determining "acceptable" detail fill was subjective, but was consistent throughout the testing process. Mint engineers who were assigned to the technical team routinely conduct progression strikes in the course of their day-to-day duties, and their extensive experience enabled the subjective R&D assessments to be consistent.

3.2.2. Testing Results

Before variability testing began, the Mint set up an electronic database with minimum and maximum acceptable dimensional results to make it easier to see if a material passed or failed the test, and by how much. The setup also enabled the Mint to readily see the variances within each material and judge if the material were too inconsistent. For each material, the Mint used calibrated micrometer gauges connected to a computer to enter the relevant data into the database where the Mint could analyze it.

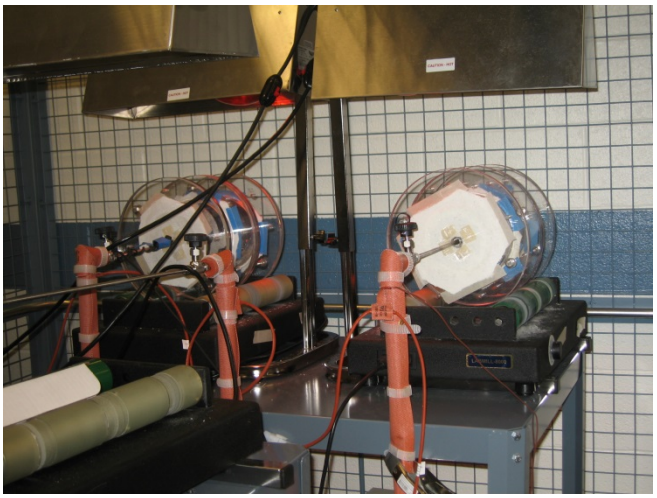
For the variability lots, the Mint used a specific dimensional data system, which generated reports for each material that showed the minimum and maximum acceptable numbers; the average, low, and high scores for each test; and a bar chart that showed the variances in the tests (typically a bell curve was seen).

For pre-production lots, the Mint used a software spreadsheet program to record results from micrometers connected to the computer and generate reports that made individual points of data easier to access.

3.2.3. Wear Test

For each material, the Mint took either one group (variability) or four groups (pre-production) of five random pieces from test strikes and put them through a two-week-long comparative wear test. Nonsense pieces were placed in a towel-lined tumbler with current coins and then tumbled with a light application of artificial sweat at 40–52 °C in a humidified environment.

Figure 3-2. Steam Test Tumblers



The facility had multiple tumblers, each with two test compartments which were lined with pleated towels. The towels overlapped slightly, introducing an occasional flip in the movement of the pieces and coins in the tumbler. Large, infrared lamps were placed above each tumbler to heat the tumblers above the condensation point of the humidified air.

Into each compartment went five sample nonsense pieces (five-cent or quarter-dollar) of a test material, along with one each of a

current one-cent, five-cent, quarter-dollar, and dollar, for a total of nine pieces in each compartment. All coins and test pieces were thoroughly cleaned before testing, and were subsequently cleaned before each measurement. Testers wore powder-free rubber gloves when handling the cleaned coins and test pieces.

The Mint measured the weight of each test piece before the wear test, once during the test, and finally at the end of the test. Edge thickness of test pieces was measured before the wear test and at the end of the test to judge deformation as compared with current material coins of the same denomination. Those same-denomination coins had been put through the same test previously to provide a baseline for weight loss and edge deformation. The Mint measured weight and thickness to the fourth decimal point, in grams for the weight and in inches for the thickness.

This was an accelerated wear test that replaced an earlier test the Mint used in Phase I. In the earlier test, there were various other materials (leather, cork, cloth) co-mingled with the test pieces and a larger amount of artificial sweat. The Mint determined the earlier test was too aggressive and not representative of actual use, especially when wear-testing plated materials. The Mint developed this optimized test procedure to address the aggressiveness noted in Phase I of the original test.

Note that this wear test was designed to be comparative (evaluate an alternative material as either better, the same or worse than the current material) and not to predict actual coin life.

To pass the Go/No-Go determination for the variability lot stage, candidate materials could only lose up to twice as much weight on a percent basis as the current material lost after the two weeks were up (i.e., exhibited at least half the life), and had to show as much dimensional durability (keep the same edge thickness), with no more than a 0.010" difference with the current coins tested previously.

3.2.4. Steam Test

The Mint took a small number of random blanks for each material and measured the color (brightness and hue) with a spectrophotometer that gave a positive "L" value for the brightness, and then an "a" value (positive for red, negative for green) and a "b" value (positive for yellow, negative for blue) for the hue.

Figure 3-3. Steam Test Autoclave

When those scores were recorded, the Mint steamed the blanks in an autoclave at 100 °C, atmospheric pressure, and 100 percent humidity to accelerate the oxidation rate compared with ambient conditions.

After this, the Mint measured the color again and recorded the difference. Note that this method was only used to evaluate the properties of the chemical layer formed during the blank preparation process. In the a and b color plan, less change meant a better protective chemical layer.

The Mint examined the tested samples under appropriate lighting for discoloration or spots.

3.2.5. Coin Sorter/Validator (CSV) Test

Many retail, public transit, financial institutions, and other industries that handle large numbers of coins use coin sorter/validator systems from numerous manufacturers. These systems take many different readings of a coin to determine the coin's diameter, edge thickness, conductivity, and permeability, among other characteristics. For Phase II, the Mint obtained a high-speed CSV for its R&D program.

Figure 3-4. High-Speed CSV

During variability lots, for each material, the Mint chose random samples of no less than 100 nonsense pieces at each of the supplier's minimum, maximum, and nominal platings, thicknesses, etc. During pre-production lots, the Mint chose at least two large samples of approximately 30,000 pieces for each material and selected at least 100 pieces from each subsequent sampling of 30,000 pieces.

The Mint then sent these pieces through the CSV to determine the material's measurements and electromagnetic characteristics, consistency across batches, and match with the current material.

To ensure that the data was accurate and reliable, the Mint kept the CSV properly calibrated at all times.

3.2.6. Hardness Test

The Mint tested a random sample of each material using a hardness tester. Blanks that were not yet annealed and ready-to-strike planchets were both tested, and so, there are "pre-annealed" and "annealed" results from this test, though some materials only have a score in one of the fields (i.e., a material that could not be annealed, or a material that came already annealed). The Mint used the Rockwell 15T scale for this test.

Figure 3-5. Hardness Tester

The test involved putting a planchet in the hardness tester, and applying a minor load to the material, which established the "zero position." A major load was then applied and removed, leaving the minor load in place. The tester then showed the depth of penetration from the zero position, on a readout in which harder materials have a higher number. For small lots (30 or fewer), each piece was tested in five different points, with the highest and lowest of the five readings disregarded. The Mint then averaged the remaining three readings for that piece's reading. For larger lots (over 30 pieces), the Mint took one reading per piece, and performed statistical analysis on the data sets, using them for comparison and evaluation.

Nominal hardness values for current materials are between 62 and 72[21], and this was the target for the candidate materials, but hardness was not a consideration for Go/No-Go.

[21] The Rockwell hardness number is relative, with no unit.

3.2.7. Electrical Conductivity Test

Conductivity is the measure of how well a material carries an electrical charge. Copper is the most conductive non-precious metal, and is used as the standard for conductivity. In 1913, due to a lack of uniformity in the value of annealed copper in various countries, the U.S. National Bureau of Standards (now the National Institute of Standards and Technology) developed the International Annealed Copper Standard (IACS) which was quickly adopted by the International Electrotechnical Commission. This standard was accepted by 1914 and is still used.

The IACS uses a percentage score to represent the conductivity of a metal. A score of 100 percent IACS translates to 58 million siemens[22] per meter at 20 °C[23], which was the conductivity of commercially pure, annealed copper when the standard was set.[24]

The Mint used a conductivity meter to test each material as blank planchets in variances of construction (minimal, nominal, and maximal). Each planchet was tested at two to four different frequencies. This test is suitable only for non-ferromagnetic materials.

[22] 1 siemens (S) is equivalent to the reciprocal of 1 ohm (1/ohm) in the International System of Units; also referred to as the "mho"; the ohm is a measure of electrical resistance, the siemens is a measure of electrical conductivity.

[23] Equates to 68 °F, or room temperature.

[24] Commercially pure, annealed copper at 20 °C today has a higher IACS than 100% because of better methods for removing impurities from the metal.

3.3. Material Tests – Variability Lots

3.3.1. CPZ (Variability Lot)

CPZ failed the wear/durability requirement, and as a result, the Mint eliminated the material from further consideration.

Progression Strikes

The Mint struck CPZ planchets at strike forces from 33 to 54 tonnes; the detail became acceptable[25] at 54 tonnes, the same tonnage as the current material, which indicated a potential for similar die life with this material.

Figure 3-6. CPZ Test Piece

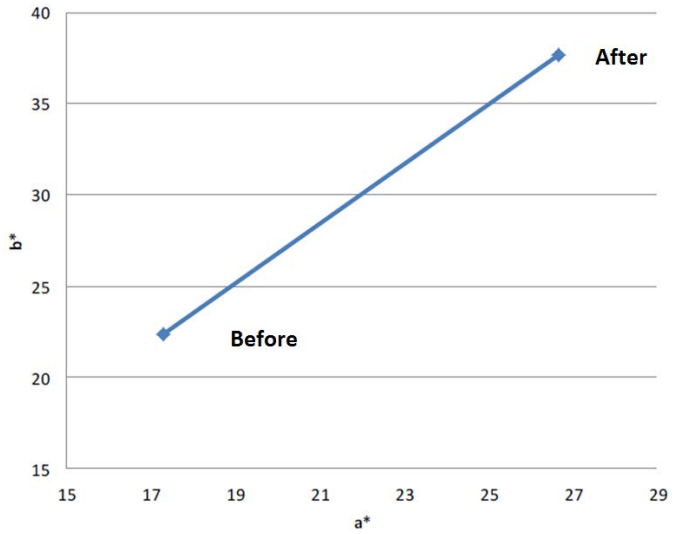
CPZ: 54 tonnes

Steam Test

The color change shown by the CPZ blanks in the variability lot steam test was noticeable, and was determined to be inferior to the current five-cent material. However, the change was within acceptable parameters set by the Mint. (The full test results are available in Appendix 10.2.1.)

[25] "Acceptable" meant sharp, square, level lettering, and fine detail that matched up visually with that in the dies.

Figure 3-7. Five-Cent CPZ Blank Color Change—Variability Lot



CPZ's color changed to a darker hue, with more yellow (higher b) and more red (higher a).

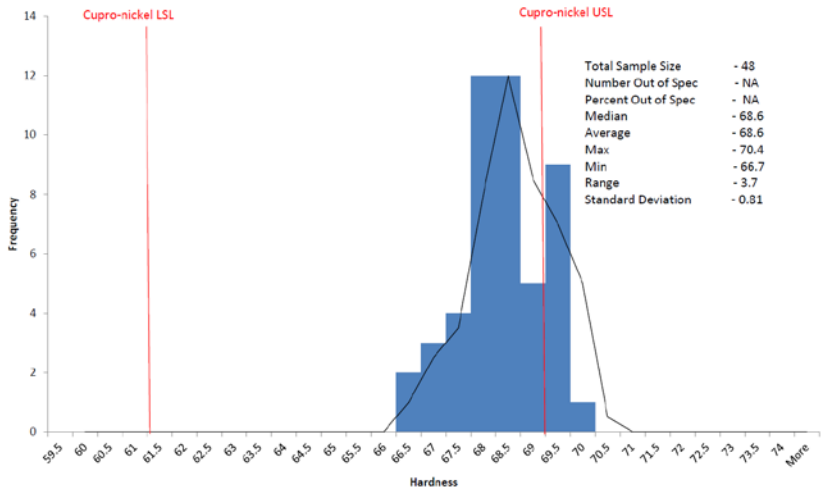
CSV Test

The CSV scans showed acceptable size and EMS measurements for a co-circulate material. (The full test results are available in Appendix 10.3.1.)

Hardness Test

The Mint tested 48 blank planchets for their hardness, using the Rockwell HR 15T scale. CPZ showed a hardness range of 66.7 to 70.4, with an average of 68.6. The range of the samples showed a hardness level slightly higher than that of the current cupronickel.

Figure 3-8. Five-Cent CPZ Planchet Hardness Test—Variability Lot



Conductivity

The Mint tested 20 random CPZ blanks each at minimal and nominal plating for their conductivity. From the lowest to the highest frequencies, CPZ yielded IACS readings of 28.36% to 29.55% and deviations among the pieces tested at each frequency were well within acceptable parameters.

Copper-Plated Zinc Go/No-Go Determination

Security

Go. CPZ was solely being considered for use in the five-cent, so security needs were minimal, given the five-cent's value and the standards in the European Vending Agency (EVA) Handbook regarding low-denomination coinage. The Mint produced nonsense pieces and tested them internally and at Coin Acceptor Manufacturers. The material yielded a unique EMS with respect to other world coins, but it did not match the current material, so it was considered a co-circulate alternative.

Recyclability

Go. Any condemned or recycled CPZ would be sent directly to the supplier for re-melting and use in future coin materials. The data suggested this would be relatively cost-neutral, with the recovered metal's value offsetting the cost of processing and melting.

Public Health/Toxicity

Go. CPZ presents no unique hazards such as radioactivity or toxicity, and is not a known allergen. Copper and zinc are used in bathroom and kitchen fixtures as well as current U.S. coinage (one-cent), so there is significant public exposure and experience with the metals in

this material. As such, the Mint was able to state that there are no unique or special hazards to humans associated with CPZ.[26] Its main hazard would be ingestion/aspiration of the material, which could cause gastro-intestinal or respiratory issues; this is unrelated to the material or its use, and so is not a greater or lesser risk for this than any other coin.

Wear Test

No Go. CPZ performed acceptably in one aspect of the wear test, weight loss. During the two-week test, it lost 3.6mg of its material compared with the 12.9mg lost by the current material, but the durability of CPZ was insufficient, causing the edges to deform 0.0165", more than the 0.010" maximum allowed. Also, the 8μm copper plating was too thin to withstand the wear, and the high points of the nonsense pieces had worn down to the zinc substrate, as shown in the photo, below. This was also evident on the pieces subjected to multiple runs through the CSV to simulate a life of wear in automated CSVs.

Figure 3-9. CPZ After Wear Test

Note the zinc exposure at edges of high points.

As a result of CPZ's low durability and the weakness of the plating, the Mint determined that the material failed this test. While plating thickness could be increased to compensate for the automated coin sorter wear test, the inherent weakness of the zinc substrate when used for the heavier five-cent (vs. the smaller/lighter one-cent) resulted in the excessive edge deformation and would not be improved by thicker plating layers. The material supplier has indicated in technical discussions that there is limited ability to improve the inherent

[26] Dogs and cats that swallow zinc-based coins may be poisoned by the zinc. (Source: CBS News http://www.cbsnews.com/news/dog-fatally-poisoned-by-one-penny/)

mechanical properties of the zinc substrate without trading off hardness for ductility. Stated differently, increasing the hardness and resistance to deformation would significantly impact the ductility and ability to strike a coin. (The full test results are available in Appendix 10.1.1.)

Co-Circulate

No-Go. CPZ showed a unique EMS, acceptable color change in its steam test, and proved to have the proper size, weight, edge thickness, and conductivity to co-circulate as a five-cent. However, CPZ failed the two-week wear test, showing worse edge deformation than the current material, and the zinc substrate began to show through at the high points on the design. As a result of this test, CPZ was dropped from consideration and was not evaluated further.

Go/No-Go Recommendation

No-Go.

3.3.2. Tin-Plated Copper-Plated Zinc (Variability Lot)

Tin-plated copper-plated zinc (TPCPZ) failed the wear requirement, and as a result, the Mint eliminated the material from further consideration.

Progression Strikes

The Mint struck five-cent TPCPZ planchets at strike forces from 50 to 66 tonnes; the detail became acceptable at 54 tonnes, the same tonnage as the current material, which indicated a potential for similar die life with this material. Then it struck quarter-dollar planchets at strike forces from 59 to 67 tonnes; the detail was acceptable at 59 tonnes, well below the current 62-tonne striking force.

TPCPZ's dimensional and design fill was superior to the current five-cent and quarter-dollar materials for the entire range of the progression strikes.

Steam Test

There was almost no color change shown by the TPCPZ blanks in the variability lot steam test, and the Mint determined TPCPZ to be superior to the current five-cent and quarter-dollar materials for this test. As shown in Figures 3-10 and 3-11, below, the "before" and "after" points are so close, marking them yields no significant data. (The full test results are available in Appendix 10.2.2.)

Figure 3-10. Five-Cent TPCPZ Blank Color Change—Variability Lot

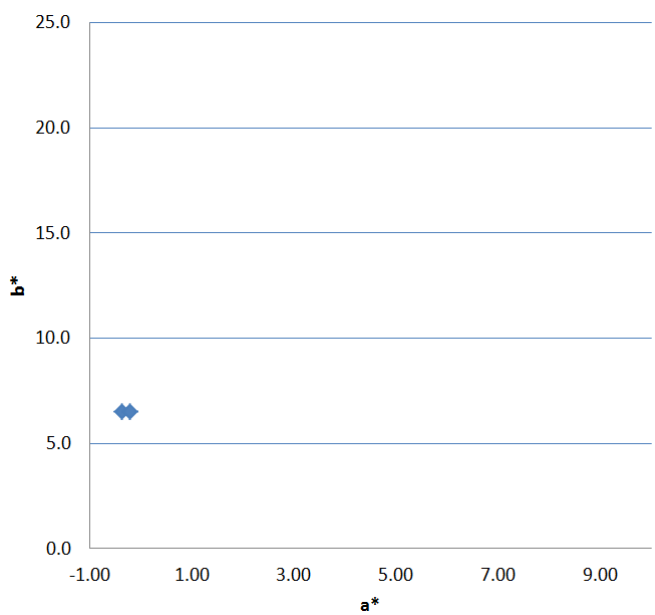
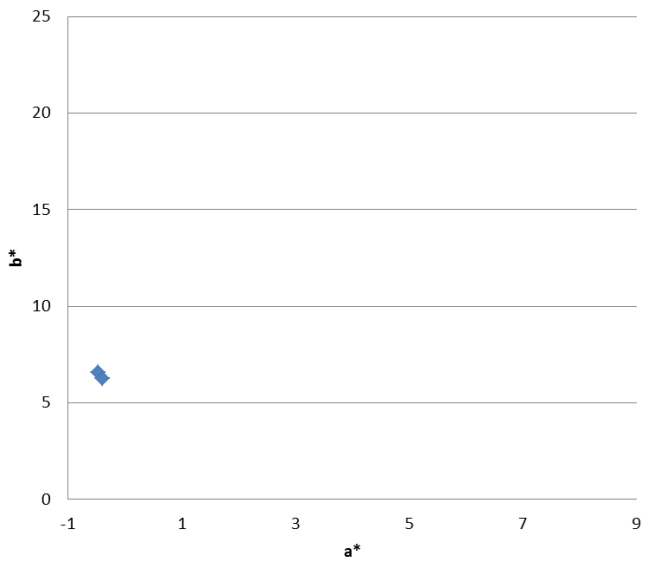


Figure 3-11. Quarter-Dollar TPCPZ Blank Color Change—Variability Lot



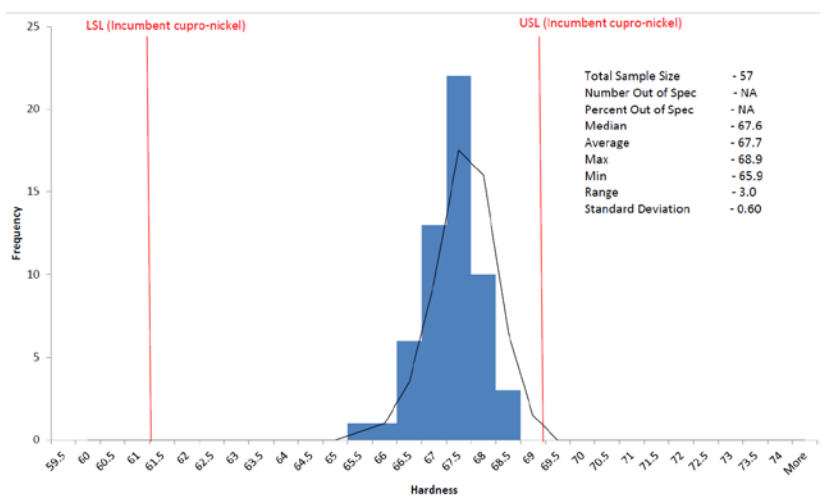
CSV Test

The CSV scans showed acceptable size and EMS measurements for a co-circulate material. (The full test results are available in Appendix 10.3.2.)

Hardness Test

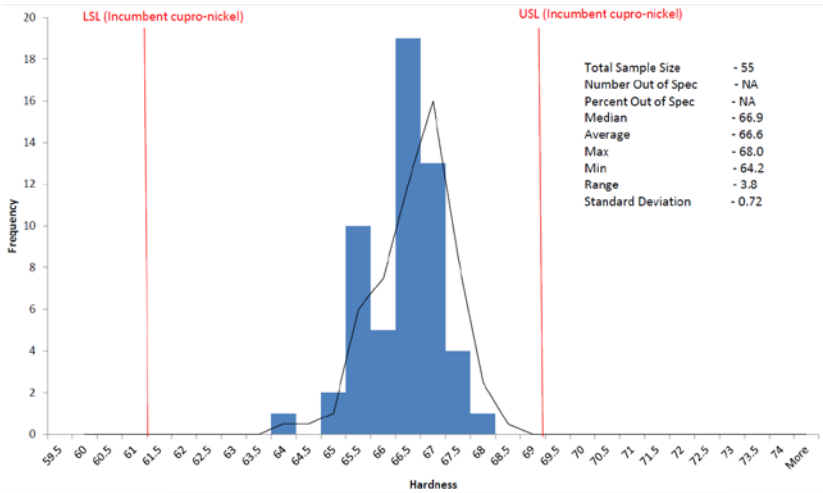
The Mint tested 57 blank five-cent planchets of the for their hardness, using the Rockwell HR 15T scale. As shown in Figure 3-12, below, TPCPZ showed a hardness range of 65.9 to 68.9, with an average of 67.6. The range of the samples showed a similar hardness level as the current cupronickel, but slightly harder.

Figure 3-12. Five-Cent TPCPZ Planchet Hardness Test—Variability Lot



Next, the Mint tested 55 blank quarter-dollar TPCPZ planchets for their hardness. As shown in Figure 3-13, below, the quarter-dollar configuration TPCPZ showed a hardness range of 64.2 to 68.0, with an average of 66.9, which was slightly harder than the current material's hardness.

Figure 3-13. Quarter-Dollar TPCPZ Planchet Hardness Test—Variability Lot



Conductivity

The Mint tested random five-cent and quarter-dollar TPCPZ blanks at minimum, nominal, and maximum plating for their conductivity. For the five-cent blanks, from the lowest to the highest frequencies, TPCPZ yielded IACS readings of 28.50% to 30.71% and deviations among the pieces tested at each frequency were well within acceptable parameters. The IACS readings for the quarter-dollar blanks were 28.48% to 30.78% with deviations well within acceptable parameters.

TPCPZ Go/No-Go Determination

Security

Go. For the five-cent, the security requirements are minimal given its value and the standards in the EVA Handbook. However, for the quarter-dollar, the security requirements are more extensive as the coin is near the breakpoint for medium-value coins in the EVA Handbook. The appropriate level of security for the quarter-dollar was still to be determined, so the material was rated as "Go" for security.

Test pieces were produced and tested both internally and at Coin Acceptor Manufacturers. The material yielded a unique EMS with respect to other world coins, but its EMS did not match the current material so it was considered a co-circulate candidate material.

Recyclability

Go. Any condemned or recycled material would go to a brass supplier for re-melting and use on future brass (non-coin) materials. Zinc and copper are the main constituents in brass which also has a tin as an additive. The data suggests that this would be relatively cost-neutral with the recovered metal units offsetting the costs of processing and melting.

Public Health/Toxicity

Go. TPCPZ has no unique hazards such as radioactivity or toxicity, and is not a known allergen. Tin, copper, and zinc are all commonly used materials and the zinc core with copper plating is currently used as U.S. coinage (one-cent) and there are no unique or special hazards to humans associated with it.[27] Its main hazard would be ingestion/aspiration of the material, which could cause gastro-intestinal or respiratory issues; this is unrelated to the material or its use, and so is not a greater or lesser risk for this than any other coin.

Wear Test

No Go. After only two days in the tumbler, the tin plating and copper plating on the TPCPZ pieces had worn almost completely away from the zinc substrate, as shown in the picture, below. The Mint conducted a second round of wear testing, which confirmed the earlier failure. The material failed this test. (The full test results are available in Appendix 10.1.2.)

Figure 3-14. TPCPZ After Wear Test

Note the fragments of plating remaining around the edge of the piece.

[27] Dogs and cats that swallow coins with a zinc core may be poisoned by the zinc. (Source: CBS News.)

Co-Circulate

No-Go. TPCPZ showed a unique EMS, acceptable color change in its steam test, and proved to have the proper size, weight, edge thickness, and conductivity to co-circulate. Unfortunately, it failed the two-week wear test, with the plating wearing away nearly completely in only two days. As a result of this test, TPCPZ was dropped from consideration and was not tested further in the pre-production lots.

Go/No-Go Recommendation

No-Go.

3.3.3. Multi-Ply-Plated Steel (Variability Lot)

Multi-Ply-Plated Steel (MPPS) passed all of its Go/No-Go criteria for both the five-cent and the quarter-dollar, except security levels needed for the quarter-dollar were still being evaluated. Testing continued through the pre-production lots for this material at that denomination. As its EMS signature and weight differ significantly from the current coins, MPPS is considered a co-circulation option.

Progression Strikes

The Mint struck five-cent and quarter-dollar MPPS planchets at strike forces from 30 to 60 tonnes. The current five-cent tonnage is 54 tonnes; at 54 and 60 tonnes, MPPS fill was poor. The Mint observed abrasive wear scratches in the progression strikes, attributed to the abrasive nature of the pure-nickel surface coating. For any extensive striking such as pre-production lots, PVD-coated dies[28] would be required.

Figure 3-14. MPPS Five-Cent Test Piece

Red arrows indicate areas of poor fill.

[28] Physical vapor deposition is a vacuum deposition method involving plasma sputter bombardment of target material to deposit thin films of that material onto surfaces (i.e., coining dies). PVD coatings are generally used to improve hardness and wear resistance. The RCM routinely uses this coating process on their numismatic and circulating dies; for further testing, the Mint sent dies to the RCM for PVD coating.

The current quarter-dollar tonnage is 62 tonnes, but the MPPS quarter-dollar nonsense pieces needed 65 tonnes to see acceptable fill in the lettering along the edge.

Figure 3-15. MPPS Quarter-Dollar Test Piece

Steam Test

There was almost no color change shown by the MPPS blanks in the variability lot steam test, and the Mint determined MPPS to be superior to the current five-cent and quarter-dollar materials for this test. As shown in Figures 3-16 and 3-17, below, the "before" and "after" points are so close, marking them yields no significant data. (The full test results are available in Appendix 10.2.4.)

Figure 3-16. Five-Cent MPPS Blank Color Change—Variability Lot

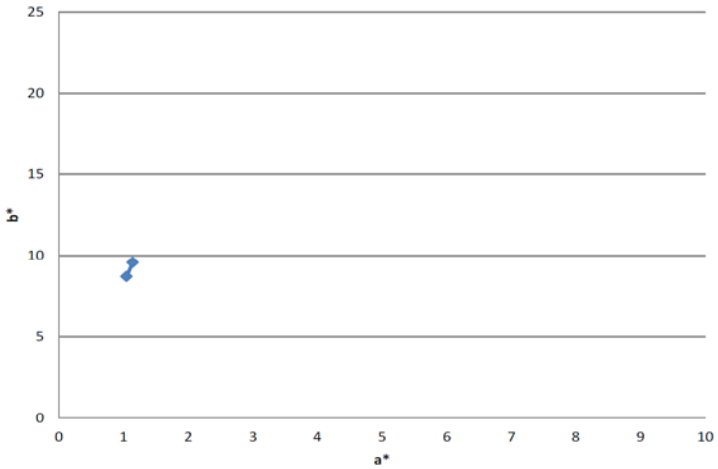
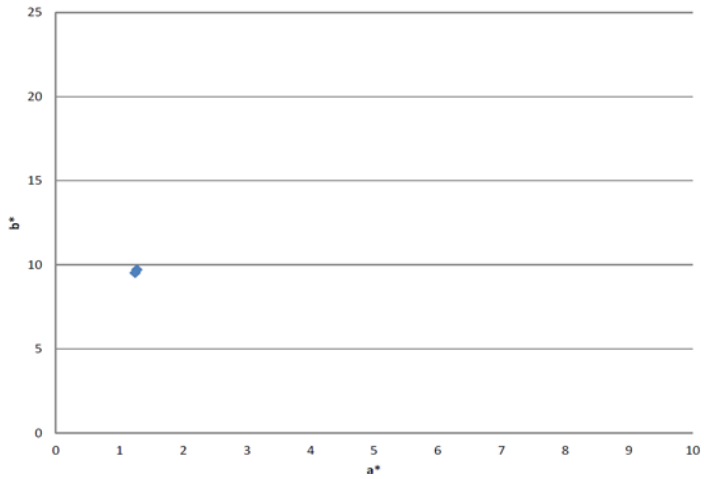


Figure 3-17. Quarter-Dollar MPPS Blank Color Change—Variability Lot



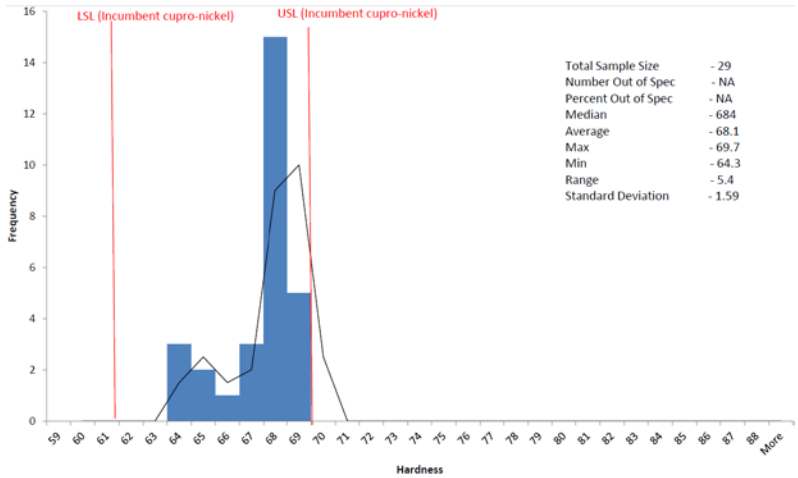
CSV Test

The CSV scans showed acceptable size and EMS measurements for a co-circulate material. (The full test results are available in Appendix 10.3.4.)

Hardness Test

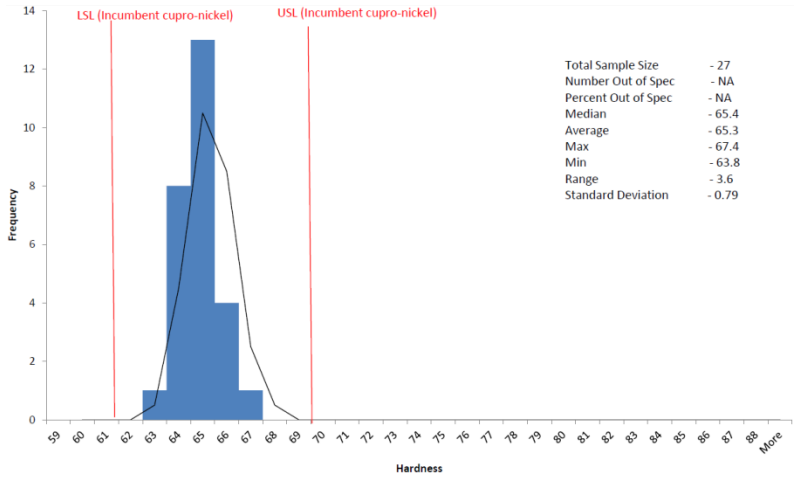
The Mint tested 29 blank MPPS five-cent planchets for their hardness, using the Rockwell HR 15T scale. As shown in Figure 3-18, below, MPPS showed a hardness range of 64.3 to 69.7, with an average of 68.1. The range of the samples showed a similar hardness level as the current cupronickel, but slightly harder.

Figure 3-18. Five-Cent MPPS Planchet Hardness Test—Variability Lot



Next, the Mint tested 27 blank quarter-dollar MPPS planchets for their hardness. As shown in Figure 3-19, below, MPPS showed a hardness range of 63.8 to 67.4, with an average of 65.3, which was almost identical to the current material's hardness.

Figure 3-19. Quarter-Dollar MPPS Planchet Hardness Test—Variability Lot



Conductivity

The conductivity test is appropriate for measuring non-ferromagnetic metals and alloys. The construction of the MPPS planchet makes this test not applicable due to the combination of non-ferromagnetic plating and ferromagnetic steel substrate, so it was not performed.

Conductivity was measured in the CSV test (see above), which uses sensors capable of measuring the relative electromagnetic properties of both ferromagnetic and non-ferromagnetic metals.

MPPS Go/No-Go Determination

Security

Go. For the five-cent, the security requirements are minimal given its value and the standards in the EVA Handbook. At the time of variability testing, no security determination had been established for the quarter-dollar, so the material was approved for pre-production testing.

Nonsense pieces were tested both internally and at coin acceptor manufacturers. MPPS exhibits a distinguishable EMS, but has a broader conductivity band that can overlap with other world coins. The steel core also makes MPPS more easily counterfeited, which has a greater potential impact on the quarter-dollar, as it is more widely used in vending.

Recyclability

Go. Any condemned or recycled material would go to a stainless steel supplier for re-melting and use on other non-coin materials. The data suggests that this would be relatively cost-neutral with the recovered metal units offsetting the cost of processing and melting. However, with the presence of copper, the ability to absorb large quantities of MPPS as stainless scrap is limited and may impact the recyclability of the larger quantities that would be generated if the material was used for U.S. coinage. The Mint contacted two domestic stainless steel mills that reported that the percentage of stainless material containing copper was 40 percent of one supplier's volume and only 15 percent of the other's. Depending on the volume and timing, then, recycling could be limited.

Public Health/Toxicity

Go. MPPS has no unique hazards such as radioactivity or toxicity, and is not a significant allergen. It is a material used in a number of applications worldwide, including coinage. There are no unique or special hazards associated with it. The nickel coating can cause skin rashes in some small portion of the population with an occurrence possibly higher than the current five-cent or quarter-dollar material which has been acceptable. Its main hazard would be ingestion/aspiration of the material, which could cause gastro-intestinal or respiratory issues; this is unrelated to the material or its use, and so is not a greater or lesser risk for this than any other coin.

Wear Test

Go. MPPS performed exceptionally well in the two-week wear test, as the five-cent nonsense pieces lost an average of 14.1mg of the material compared with the 19.0mg lost by the current material. The quarter-dollar nonsense pieces performed even better, losing only an average of 4.4mg compared with the 27.2mg lost by the current material. In the five-cent configuration, MPPS' edge deformation was less than the current material, and in the quarter-dollar configuration, MPPS deformed only 0.005" more than the current material, well within the 0.01" allowed. (The full test results are available in Appendix 10.1.4.)

Figure 3-20. MPPS Quarter-Dollar After Wear Test

Co-Circulate

Go. MPPS showed acceptable color change in its steam test, and proved to have the proper size, weight, edge thickness, and conductivity to co-circulate. It also showed a superior resistance to wear, but needed more tonnage to strike and caused wear to the dies. The Mint determined that this likely could be mitigated with further testing. Security for the quarter-dollar was still being determined, so the team considered MPPS a valid candidate for co-circulation in pre-production testing for both the five-cent and the quarter-dollar.

Go/No-Go Recommendation

Go.

3.3.4. Nickel-Plated Steel (Variability Lot)

Nickel-Plated Steel (NPS) passed all of its Go/No-Go criteria for both the five-cent and the quarter-dollar, except the Mint was still evaluating the security levels needed for the quarter-dollar. Testing continued through the pre-production lots for this denomination. As its EMS signature and weight differ significantly from the current coins, NPS is considered a co-circulation option.

Progression Strikes

The Mint struck five-cent NPS planchets at strike forces from 30 to 65 tonnes. The current five-cent tonnage is 54 tonnes, and at this tonnage, NPS fill matched the current material's, but edge thickness was insufficient until 58 tonnes. Abrasive wear scratches in the progression strikes were attributed to the abrasive nature of the pure-nickel surface layer. For any extensive striking such as pre-production runs, PVD-coated dies would be required.

Figure 3-21. NPS Five-Cent Test Piece

Red arrows indicate abrasive wear scratches

The Mint then struck quarter-dollar planchets at strike forces from 36 to 73 tonnes. NPS fill and coin diameter were unacceptable across the entire range of progression strikes.

Figure 3-22. NPS Quarter-Dollar Test Piece

Red areas indicate insufficient fill.

Steam Test

The NPS blanks showed a slight color change in the variability lot steam test, making the blanks darker, but the change was small. The Mint determined NPS to be superior to the current five-cent and quarter-dollar materials for this test. As shown in Figures 3-23 and 3-24, below, the five-cent and quarter-dollar saw nearly identical color changes, with the hue going slightly more yellow and more red. (The full test results are available in Appendix 10.2.3.)

Figure 3-23. Five-Cent NPS Blank Color Change—Variability Lot

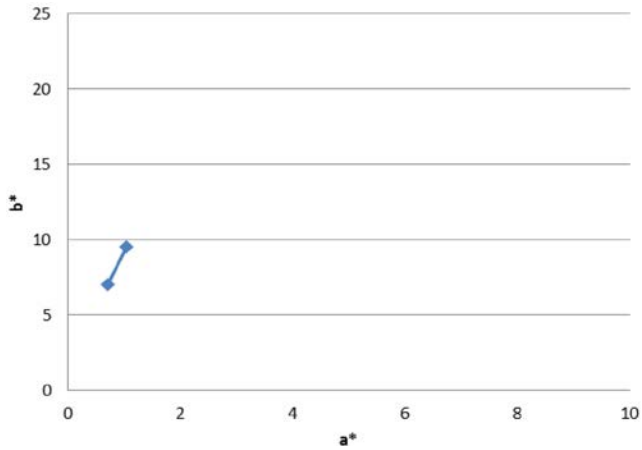
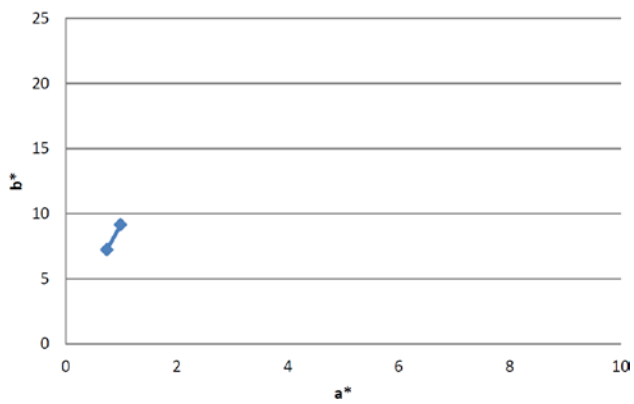


Figure 3-24. Quarter-Dollar NPS Blank Color Change—Variability Lot



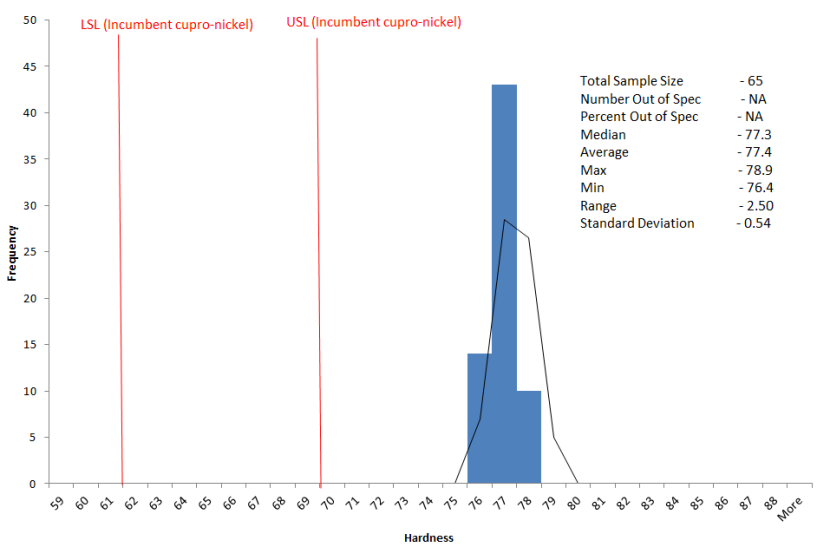
CSV Test

The CSV scans showed acceptable size and EMS measurements for consideration as a co-circulate material. (The full test results are available in Appendix 10.3.3.)

Hardness Test

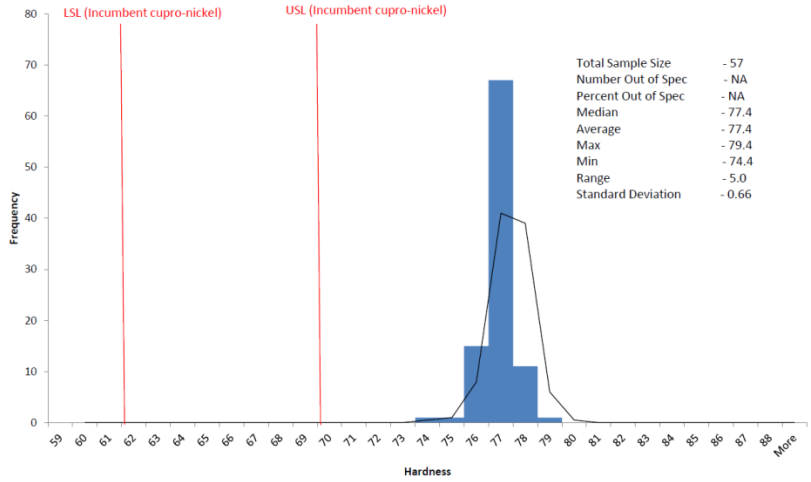
The Mint tested 65 blank NPS five-cent planchets for their hardness, using the Rockwell HR 15T scale. As shown in Figure 3-25, below, NPS showed a hardness range of 76.4 to 78.9, with an average of 77.3, well above the upper limit for the current cupronickel.

Figure 3-25. Five-Cent NPS Planchet Hardness Test—Variability Lot



Next, the Mint tested 57 blank NPS quarter-dollar planchets for their hardness. As shown in Figure 3-26, below, NPS showed a hardness range of 74.4 to 79.4, with an average of 77.4. The range of the samples showed a similar hardness level to the five-cent pieces, well above the upper limit for the current cupronickel.

Figure 3-26. Quarter-Dollar NPS Planchet Hardness Test—Variability Lot



Conductivity

The conductivity test is appropriate for measuring non-ferromagnetic metals and alloys. The construction of the NPS planchet makes this test not applicable due to the combination of non-ferromagnetic plating and ferromagnetic steel substrate, so it was not performed.

Conductivity was measured in the CSV test (see above), which uses sensors capable of measuring the relative electromagnetic properties of both ferromagnetic and non-ferromagnetic metals.

NPS Go/No-Go Determination

Security

Go. For the five-cent, the security requirements are minimal given its value and the standards in the EVA Handbook. However, for the quarter-dollar, the security requirements are more extensive as the coin is near the breakpoint for medium-value coins in the EVA Handbook. At the time of variability testing, no security determination had been established for the quarter-dollar, so the material was approved for pre-production testing.

Recyclability

Go. The recycle path for any condemned or recycled material would be directly to a stainless steel supplier for re-melting and for use on other, non-coin materials. The data suggests that this would be relatively cost-neutral with the recovered metal units offsetting the costs of processing and melting. As iron (steel) and nickel are both present in all stainless steel grades, there would not be any limitation on accepting the scrap for remelting.

Public Health/Toxicity

Go. NPS has no unique hazards such as radioactivity or toxicity, and is not a significant allergen. It is a material used in a number of applications worldwide, including coinage. There are no unique or special hazards associated with it. The nickel coating can cause skin rashes in some small portion of the population with an occurrence possibly higher than the current five-cent or quarter-dollar material which has been acceptable. Its main hazard would be ingestion/aspiration of the material, which could cause gastro-intestinal or respiratory issues; this is unrelated to the material or its use, and so is not a greater or lesser risk for this than any other coin.

Wear Test

Go. NPS performed supremely well in the two-week wear test, as the five-cent nonsense pieces lost an average of 7.7mg of the material compared with the 24.5mg lost by the current material. The quarter-dollar nonsense pieces performed equally well, losing only an average of 5.8mg compared with the 27.2mg lost by the current material. In the five-cent configuration, NPS' edge deformation was less than the current material; in the quarter-dollar configuration, NPS' edge deformation was identical to the current material. (The full test results are available in Appendix 10.1.3.)

Figure 3-27. NPS Quarter-Dollar After Wear Test

NPS quarter-dollar nonsense piece after wear test

Co-Circulate

Go. NPS showed acceptable color change in its steam test, and proved to have the proper size, weight, edge thickness, and conductivity to co-circulate. It also showed a superior resistance to wear, but needed more tonnage to strike and caused wear to the dies. The Mint determined that this could be mitigated with further testing. Security for the quarter-dollar

was still being determined, so the team considered NPS a valid candidate for co-circulation in pre-production testing for both the five-cent and the quarter-dollar.

Go/No-Go Recommendation

Go.

3.3.5. Cupronickel 80/20 from Supplier A (80/20A) (Variability Lot)

Cupronickel 80/20 from Supplier A (80/20A) passed all of its Go/No-Go criteria for the five-cent except for the EMS test. 80/20A was intended to be a seamless alternative, but its EMS was too far out of the current material's range. The Mint pursued an alternative composition for 80/20 from Supplier B (see 3.3.6), and 80/20A was deferred from further testing during Phase II to allow the Mint to focus on refining the B composition, which was closer to the current material's EMS.

Progression Strikes

Due to a limited number of blanks available for testing, the Mint did not conduct progression strikes for 80/20A. Instead, the Mint struck five-cent planchets at the current five-cent tonnage of 54 tonnes. At this tonnage, 80/20A achieved acceptable design and dimensional fill that was similar to those of the current five-cent. The Mint observed no difficult-to-fill areas.

Figure 3-28. 80/20A Test Piece (54T Strike)

Steam Test

The 80/20A blanks showed random, large, water stains in the variability lot steam test, making the blanks' test results exceedingly variable and rendering the test inconclusive. (The full test results are available in Appendix 10.2.5.)

CSV Test

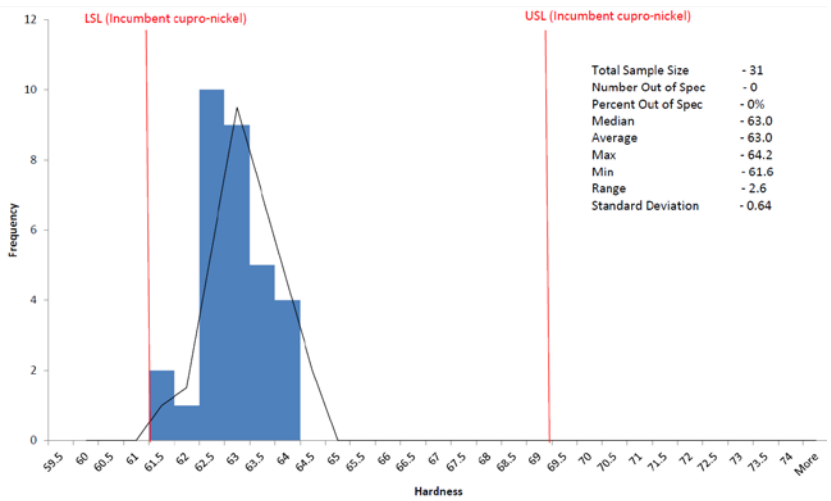
The CSV scans showed acceptable size measurements but unacceptable EMS results for consideration as a seamless material. (The full test results are available in Appendix 10.3.5.)

Hardness Test

The Mint tested 31 blank 80/20A five-cent planchets for their hardness, using the Rockwell HR 15T scale. As shown in Figure 3-29, below, 80/20A showed a hardness range of 61.6 to

64.2, with an average of 63.0. The range of the samples showed a hardness level well within the range of the current cupronickel but slightly softer on average. For cupronickel, the hardness was not a function of just the composition, but also the annealing. These pieces were subject to a laboratory anneal which contributed to the lower hardness observed.

Figure 3-29. Five-Cent 80/20A Planchet Hardness Test—Variability Lot



Conductivity

The Mint tested six batches of five random 80/20A blanks each at minimal and nominal composition for their conductivity. From the lowest to the highest frequencies, 80/20A yielded IACS readings of 5.61% to 6.93% and deviations among the pieces tested at each frequency were well within acceptable parameters.

80/20A Go/No-Go Determination

Security

Go. For the five-cent, the security requirements are minimal given its value and the standards in the EVA Handbook. 80/20A proved to have the same level of security as the current material, with a unique EMS, an uncommon alloy, and no use in other mints.

Recyclability

Go. The recycle path for any condemned or recycled material would be directly to the coin material supplier for re-melting and for use on coin materials. The data suggests that this would be cost-positive with the recovered metal units more than offsetting the costs of processing and melting.

Public Health/Toxicity

Go. As a cupronickel alloy, there are no unique hazards such as radioactivity or toxicity, and it is not a significant allergen. The nickel content can be a cause for skin rashes in some small portions of the population with an occurrence similar to the current five-cent material. Its main hazard would be ingestion/aspiration of the material, which could cause gastro-intestinal or respiratory issues; this is unrelated to the material or its use, and so is not a greater or lesser risk for this than any other coin.

Wear Test

Go. 80/20A performed well in the two-week wear test, as the five-cent nonsense pieces lost an average of 19.5mg of the material compared with the 20.3mg lost by the current material. Edge deformation in the five-cent configuration was only 0.005" more than the current cupronickel, half of the 0.010" allowable deformation. (The full test results are available in Appendix 10.1.5.)

Figure 3-30. 80/20A After Wear Test

Seamless

No-Go. 80/20A showed staining in its steam test, but proved to have the proper size, weight, edge thickness, and conductivity for a seamless candidate. It also showed good resistance to wear, and comparable strike tonnage. Its EMS, however, was too far out of the acceptable range for a seamless candidate. The team therefore deferred 80/20A as a candidate.

Go/No-Go Recommendation

No-Go.

3.3.6. Cupronickel 80/20 from Supplier B (80/20B) (Variability Lot)

Cupronickel 80/20 from Supplier B (80/20B) passed all of its Go/No-Go criteria for the five-cent as a seamless alternative. The Mint requested this material as a development step in conjunction with the 80/20A, and had the supplier change the material to 77% Cu/19.7% Ni/3.3% Mn, which showed a promising EMS match.

Progression Strikes

Due to a limited number of blanks available for testing, the Mint did not conduct progression strikes for 80/20B. Instead, the Mint struck five-cent planchets at the current five-cent tonnage of 54 tonnes. At this tonnage, 80/20B achieved acceptable design and dimensional fill that was similar to those of the current five-cent. The Mint observed no difficult-to-fill areas.

Figure 3-31. 80/20B Test Piece (54T Strike)

Steam Test

The 80/20B blanks showed random, large, water stains in the variability lot steam test, making the blanks' test results exceedingly variable and rendering the test inconclusive. (The full test results are available in Appendix 10.2.6.)

CSV Test

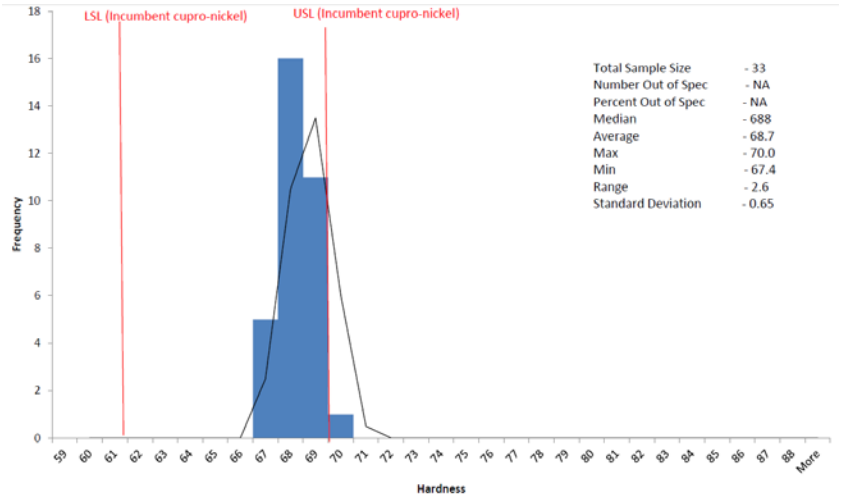
The CSV scans showed acceptable size measurements and acceptable EMS results for consideration as a potentially seamless material with minor adjustments to the composition. (The full test results are available in Appendix 10.3.6.)

Hardness Test

The Mint tested 33 blank 80/20B five-cent planchets for their hardness, using the Rockwell HR 15T scale. As shown in Figure 3-32, below, 80/20B showed a hardness range of 67.4 to 70.0, with an average of 68.7. The range of the samples showed a hardness level well within

the range of the current cupronickel but slightly harder on average. Whether this was related to composition changes, use of a laboratory anneal or both could not be determined.

Figure 3-32. Five-Cent 80/20B Planchet Hardness Test—Variability Lot



Conductivity

The Mint tested three batches of 25 random 80/20B blanks each at minimal and nominal composition for their conductivity. From the lowest to the highest frequencies, 80/20B yielded IACS readings of 5.00% to 5.99% and deviations among the pieces tested at each frequency were well within acceptable parameters.

80/20B Go/No-Go Determination

Security

Go. For the five-cent, the security requirements are minimal given its value and the standards in the EVA Handbook. 80/20B proved to have the same level of security as the current material, with a unique EMS, an uncommon alloy, and no use in other mints.

Recyclability

Go. Any condemned or recycled material would go directly to the coin material supplier for re-melting and for use on coin materials. The data suggests that this would be cost positive with the recovered metal units more than offsetting the costs of processing and melting.

Public Health/Toxicity

Go. As a cupronickel alloy, there are no unique hazards such as radioactivity or toxicity, and it is not a significant allergen. The nickel content can be a cause for skin rashes in some small portions of the population with an occurrence similar to the current five-cent material, which has been acceptable. Its main hazard would be ingestion/aspiration of the material,

which could cause gastro-intestinal or respiratory issues; this is unrelated to the material or its use, and so is not a greater or lesser risk for this than any other coin.

Wear Test

Go. 80/20B performed well in the two-week wear test, as the five-cent nonsense pieces lost an average of 16.8mg of their material compared with the average of 19mg that the current pieces lost. Edge deformation in the five-cent configuration was measured at the 0.010" allowable deformation. (The full test results are available in Appendix 10.1.6.)

Figure 3-33. 80/20B After Wear Test

Seamless

Go. 80/20B showed staining in its steam test, but proved to have the proper size, weight, edge thickness, and conductivity for a potentially seamless candidate. It also showed good resistance to wear, and comparable strike tonnage. The material has an EMS that can be read by vending machines and other coin handling equipment. Its signature is very similar to that of the current material and could potentially be seamless with further composition changes.

Go/No-Go Recommendation

Go.

3.4. Pre-Production Testing

The materials that passed Go/No-Go—nickel-plated steel, multi-ply-plated steel, and 80/20B—were subjected to many of the same tests in pre-production as they saw in variability. The materials were purchased in their standard configurations (not purchased in minimum, maximum, and nominal variances) expected to be seen in normal production.

Die life and die wear were not tested in variability lots, but both were considerations in pre-production testing. Other tests that had been performed in variability lots (wear, steam color change, CSV) were applied to the pre-production lots to determine how well the materials performed at their standard configurations.

Materials in pre-production testing were put through a down-selection process at the end of testing, in which they each were measured against current coinage materials to determine their feasibility for use in U.S. coinage.

Both nickel-plated steel and multi-ply-plated steel were tested in five-cent and quarter-dollar configurations while 80/20B was tested only in the five-cent configuration (with the understanding that it could replace the current clad material in the dime, quarter-dollar, and half-dollar if it passed as a seamless alternative for the cupronickel five-cent).

3.4.1. CPZ Pre-Production Data

The Mint purchased CPZ for pre-production and the pre-production tests were completed before the Mint had finalized the optimization of the wear test. Therefore, when CPZ failed its Go/No-Go determination (due to durability of plating thickness and substrate), even though the Mint had already run the pre-production tests, CPZ was not put through a down-selection process. (CPZ's pre-production test data is included in this report only as reference through Appendix 10.4.)

3.4.2. Down-Selection Matrices

The following tables summarize the down-selection process for the co-circulate materials that passed Go/No-Go. In all cases, criteria were rated in two tiers: Comparable or Better, and Less than Current.

Multi-Ply-Plated Steel (Five-Cent)

Alternative Metals Viability					
Factor	Description	Rating Comparable or Better Less than Current	Justifications & Comments	Judging Rubric	
Cost (per unit)	Total unit cost including consideration for capital expenditures vs. anticipated material savings	$0.0547	Estimated cost is $0.0547/unit, $0.0262 less (32% lower) than current.	X	Over 11% lower than current ($0.0809)
					Up to 10% lower than current
Environmental Impact	No change or better compared to current for internal operations and external fabricator	Comparable or Better	Operation of plating should be considered major change to waste stream, but can be effectively mitigated.	X	No changes, or changes to waste stream that can be effectively mitigated
					Unmitigated environmental impacts
Supply Chain	Future availability of the metal and a competitive supply chain - more than one fabricator/supplier	Less than Current	All materials are in adequate supply; Royal Canadian Mint holds patent for fabrication process which controls supplier base.		Adequate raw metal supply available; at least two established suppliers
				X	Adequate raw metal supply available; one supplier or supplier(s) is not proven
Coinability	Crack/piece-out incidences are less than or equal to our current, die life is acceptable	Less than Current	Plated steel die failure proved significantly higher than current. Experience at other mints suggests design changes could improve performance.		Considering the number of strikes before die retirement, die surface crack/piece-out incidence rates are similar or less than standard crown/relief test dies (current)
				X	Considering the number of strikes before die retirement, die surface crack/piece-out incidence rates are greater than standard crown/relief test dies (current)
Recyclability	Ease of recycling and value of metal recovery	Less than Current	Material recyclable, for non-coin use only; issue with volume of coins recycled; market limited due to copper content.		Similar or higher metal value recoverable in recycling, including handling costs
				X	Disposed of with reduced or no metal value in recovery, no handling cost to US Mint
Durability	Tarnish and corrosion resistance Acceptable durability/wear	Comparable or Better	Wear rate 82% lower than current; minimal discoloration.	X	Minimal or no discoloration and same or reduced wear
					Significant discoloration and increased wear
Counterfeit/Slug Vulnerability	Uniqueness among world coins, limited use of lesser value foreign coins, tokens or easily produced counterfeit devices	Less than Current	Commonly used, readily available material; ferromagnetic core; plating easily replicated; no unique EMS found.		Discrete or unique EMS, using common or uncommon materials and fabrication process
				X	No unique EMS, using common material and fabrication processes; easily counterfeited

Nickel-Plated Steel (Five-Cent)

Alternative Metals Viability					
Factor	Description	Rating Comparable or Better Less than Current	Justifications & Comments	Judging Rubric	
Cost (per unit)	Total unit cost including consideration for capital expenditures vs. anticipated material savings	$0.0611	Estimated cost is $0.0611/unit, $0.0176 less (22% lower) than current.	X	Over 11% lower than current ($0.0787)
					Up to 10% lower than current
Environmental Impact	No change or better compared to current for internal operations and external fabricator	Comparable or Better	Operation of plating should be considered major change to waste stream, and can be effectively mitigated.	X	No changes, or changes to waste stream that can be effectively mitigated
					Unmitigated environmental impacts
Supply Chain	Future availability of the metal and a competitive supply chain - more than one fabricator/supplier	Comparable or Better	All materials are in adequate supply; two existing suppliers of this material.	X	Adequate raw metal supply available; at least two established suppliers
					Adequate raw metal supply available; one supplier or supplier(s) is not proven
Coinability	Crack/piece-out incidences are less than or equal to our current, die life is acceptable	Less than Current	Plated steel die failure proved significantly higher than current. Experience at other mints suggests design changes could improve performance.		Considering the number of strikes before die retirement, die surface crack/piece-out incidence rates are same or less than standard crown/relief test dies (current)
				X	Considering the number of strikes before die retirement, die surface crack/piece-out incidence rates are greater than standard crown/relief test dies (current)
Recyclability	Ease of recycling and value of metal recovery	Less than Current	Material recyclable, but only for non-coin use. Material sees flexible use in recycling with only nickel in its plating.		Similar or higher metal value recoverable in recycling, including handling costs
				X	Disposed of with reduced or no metal value in recovery, no handling cost to US Mint
Durability	Tarnish and corrosion resistance; Acceptable durability/wear	Comparable or Better	Wear rate 85% lower than current; no significant discoloration.	X	Minimal or no discoloration and same or reduced wear
					Significant discoloration and increased wear
Counterfeit/Slug Vulnerability	Uniqueness among world coins, limited use of lesser value foreign coins, tokens or easily produced counterfeit devices	Less than Current	Commonly used, readily available material; ferromagnetic core; plating easily replicated; no unique EMS found.		Discrete or unique EMS, using common or uncommon materials and fabrication process
				X	No unique EMS, using common material and fabrication processes; easily counterfeited

Stainless Steel (Five-Cent)

Alternative Metals Viability					
Factor	Description	Rating Comparable or Better Less than Current	Justifications & Comments	Judging Rubric	
Cost (per unit)	Total unit cost including consideration for capital expenditures vs. anticipated material savings	$0.0583	Estimated cost is $0.0583/unit, $0.0204 less (26% lower) than current.	X	Over 11% lower than current ($0.0787)
					Up to 10% lower than current
Environmental Impact	No change or better compared to current for internal operations and external fabricator	Comparable or Better	Similar to current waste stream.	X	No changes, or changes to waste stream that can be effectively mitigated
					Unmitigated environmental impacts
Supply Chain	Future availability of the metal and a competitive supply chain - more than one fabricator/supplier	TBD	Raw materials in good supply; one of two recommended materials is patent pending, which could impact supply chain.		Adequate raw metal supply available; at least two established suppliers
					Adequate raw metal supply available; one supplier or supplier(s) is not proven
Coinability	Crack/piece-out incidences are less than or equal to our current, die life is acceptable	TBD	Limited testing. Larger scale test warranted on two 3XX series grades.		Considering the number of strikes before die retirement, die surface crack/piece-out incidence rates are similar or less than standard crown/relief test dies (cupronickel baseline)
					Considering the number of strikes before die retirement, die surface crack/piece-out incidence rates are greater than standard crown/relief test dies (cupronickel baseline)
Recyclability	Ease of recycling and value of metal recovery	Comparable or Better	Monolithic material that can be 100% recycled into future coin use.	X	Any metal value recoverable in recycling, including handling costs
					Disposed of with no metal value in recovery, no handling cost to US Mint
Durability	Tarnish and corrosion resistance Acceptable durability/wear	Comparable or Better	18-9 LW—Wear rate 98% lower than current; Rittenhouse 52—Wear rate 95% lower than current; No discoloration in either	X	Minimal or no discoloration and same or reduced wear
					Significant discoloration and increased wear
Counterfeit/Slug Vulnerability	Uniqueness among world coins, limited use of lesser value foreign coins, tokens or easily produced counterfeit devices	Less than Current	Commonly used, readily available material; no unique EMS found.		Discrete or unique EMS, using common or uncommon materials and fabrication process
				X	No unique EMS, using common material and fabrication processes; easily counterfeited

Multi-Ply-Plated Steel (Quarter-Dollar)

Alternative Metals Viability					
Factor	Description	Rating Comparable or Better Less than Current	Justifications & Comments	Judging Rubric	
Cost (per unit)	Total unit cost including consideration for capital expenditures vs. anticipated material savings	$0.0651	Estimated cost is $0.0651/unit, $0.0261 less (29% lower) than current.	X	Over 11% lower than current ($0.0912)
					Up to 10% lower than current
Environmental Impact	No change or better compared to current for internal operations and external fabricator	Comparable or Better	Operation of plating should be considered major change to waste stream, but can be effectively mitigated.	X	No changes, or changes to waste stream that can be effectively mitigated
					Unmitigated environmental impacts
Supply Chain	Future availability of the metal and a competitive supply chain - more than one fabricator/supplier	Less than Current	All materials are in adequate supply; Royal Canadian Mint holds patent for fabrication process which controls supplier base.		Adequate raw metal supply available; at least two established suppliers
				X	Adequate raw metal supply available; one supplier or supplier(s) is not proven
Coinability	Crack/piece-out incidences are less than or equal to our current, die life is acceptable	Less than Current	Plated steel die failure proved significantly higher than current. Experience at other mints suggests design changes could improve performance.		Considering the number of strikes before die retirement, die surface crack/piece-out incidence rates are similar or less than standard crown/relief test dies (cupronickel baseline)
				X	Considering the number of strikes before die retirement, die surface crack/piece-out incidence rates are greater than standard crown/relief test dies (cupronickel baseline)
Recyclability	Ease of recycling and value of metal recovery	Less than Current	Scrap market limited due to copper content. Material recyclable, for non-coin use only; issue with volume of coins recycled.		Similar or higher metal value recoverable in recycling, including handling costs
				X	Disposed of with reduced or no metal value in recovery, no handling cost to US Mint
Durability	Tarnish and corrosion resistance Acceptable durability/wear	Comparable or Better	Wear rate 84% lower than current; minimal discoloration.	X	Minimal or no discoloration and same or reduced wear
					Significant discoloration and increased wear
Counterfeit/Slug Vulnerability	Uniqueness among world coins, limited use of lesser-value foreign coins, tokens or easily produced counterfeit devices	Less than Current	Commonly used, readily available material; ferromagnetic core; plating easily replicated; no unique EMS found; lesser-value foreign coins (e.g., Philippine 1-peso coin, worth $0.02) match material and size.		Discrete or unique EMS, using common or uncommon materials and fabrication process
				X	No unique EMS, using common material and fabrication processes; easily counterfeited

Nickel-Plated Steel (Quarter-Dollar)

Alternative Metals Viability					
Factor	Description	Rating Comparable or Better Less than Current	Justifications & Comments	Judging Rubric	
Cost (per unit)	Total unit cost including consideration for capital expenditures vs. anticipated material savings	$0.0676	Estimated cost is $0.0676/unit, $0.0236 less (26% lower) than current.	X	Over 11% lower than current ($0.0912)
					Up to 10% lower than current
Environmental Impact	No change or better compared to current for internal operations and external fabricator	Comparable or Better	Operation of plating should be considered major change to waste stream, and can be effectively mitigated	X	No changes, or changes to waste stream that can be effectively mitigated
					Unmitigated environmental impacts
Supply Chain	Future availability of the metal and a competitive supply chain - more than one fabricator/supplier	Comparable or Better	All materials are in adequate supply; two existing suppliers of this material.	X	Adequate raw metal supply available; at least two established suppliers
					Adequate raw metal supply available; one supplier or supplier(s) is not proven
Coinability	Crack/piece-out incidences are less than or equal to our current, die life is acceptable	Less than Current	Plated steel die failure proved significantly higher than current. Experience at other mints suggests design changes could improve performance.		Considering the number of strikes before die retirement, die surface crack/piece-out incidence rates are similar or less than standard crown/relief test dies (cupronickel baseline)
				X	Considering the number of strikes before die retirement, die surface crack/piece-out incidence rates are greater than standard crown/relief test dies (cupronickel baseline)
Recyclability	Ease of recycling and value of metal recovery	Less than Current	Material recyclable, but only for non-coin use. Material sees flexible use in recycling with only nickel in its plating.		Similar or higher metal value recoverable in recycling, including handling costs
				X	Disposed of with reduced or no metal value in recovery, no handling cost to US Mint
Durability	Tarnish and corrosion resistance Acceptable durability/wear	Comparable or Better	Wear rate 72% lower than current; no significant discoloration.	X	Minimal or no discoloration and same or reduced wear
					Significant discoloration and increased wear
Counterfeit/Slug Vulnerability	Uniqueness among world coins, limited use of lesser value foreign coins, tokens or easily produced counterfeit devices	Less than Current	Commonly used, readily available material; ferromagnetic core; plating easily replicated; no unique EMS found; lesser-value foreign coins (e.g., Nigerian 50-Kobo coin, worth $0.003) match material and size.		Discrete or unique EMS, using common or uncommon materials and fabrication process
				X	No unique EMS, using common material and fabrication processes; easily counterfeited

3.4.3. Multi-Ply-Plated Steel (Pre-Production Lot)

For pre-production testing, the upset profiles of the Multi-Ply-Plated Steel (MPPS) planchets were modified from those used in variability lots. MPPS passed its down-selection criteria for the five-cent, with Comparable or Better in half of its criteria, but it rated Less than Current in four of the six criteria for the quarter-dollar, including for coinability and counterfeit/slug vulnerability. MPPS showed insufficient fill in both five-cent and quarter-dollar denominations in the progression strikes, only seeing complete fill above the current strike force, and seeing a significantly greater rate of die failure than seen with the current material.

The RCM PVD-coated the dies for pre-production testing, and the coating worked to prevent abrasive wear when striking the nickel surface of the planchets. Polishing the dies before PVD coating extended the die life, but the dies still failed in under 250,000 strikes (less than half the baseline of 500,000 strikes).

Progression Strikes

The Mint struck five-cent MPPS planchets at strike forces from 20 to 60 tonnes. The current five-cent tonnage is 54 tonnes, and at this and 56 tonnes, MPPS fill was poor. The PVD coating on the dies succeeded in preventing abrasive wear scratches from appearing in struck pieces.

Figure 3-34. MPPS Five-Cent Test Piece (56T Strike)

The top of Martha's bonnet, near the upper-left edge, shows insufficient fill

The Mint struck quarter-dollar MPPS planchets at strike forces from 36 to 64 tonnes. The current quarter-dollar tonnage is 62 tonnes; design/border fill was acceptable at 55 tonnes, but the MPPS nonsense pieces needed 64 tonnes to see acceptable fill in the lettering along the edge. The early fill at the border likely "locked" the metal at the border of the planchets, preventing the material in the center of the planchet from flowing out to the border and filling in the letters in the die. This necessitated the increase in strike force that may have contributed to die failure.

Figure 3-35. MPPS Quarter-Dollar Test Piece (64T Strike)

The Mint determined that five-cent and quarter-dollar MPPS pieces struck with polished, PVD-coated dies performed worse than with the current material in terms of strike force and die life.

The Mint also observed a greater rate of crack/piece-out incidents and a higher die-life-failure rate than the current material, seeing die pairs last an average of 200,000 strikes before they had to be replaced (as compared to the nominal 500,000). Two sets of unpolished, PVD-coated dies saw cracks form at just over 20,000 strikes, illustrating that polishing of the die would be necessary.

Further research will be needed to determine what the optimized die life will be, but it is anticipated to be fewer than 500,000 strikes. RCM's current average die life, after years of producing MPPS coins, is 350,000 strikes. A financial analysis can be done on how the loss in productivity impacts the anticipated material cost savings.

Steam Test

There was little color change shown by the MPPS blanks in the pre-production lot steam test, and the Mint determined MPPS to be superior to the current five-cent and quarter-dollar materials for this test. The results are shown in Figures 3-36 and 3-37, below, with the "before" point lower and to the left of the "after" point in each graph. (The full test results are available in Appendix 10.5.2.)

Figure 3-36. Five-Cent MPPS Blank Color Change—Pre-Production Lot

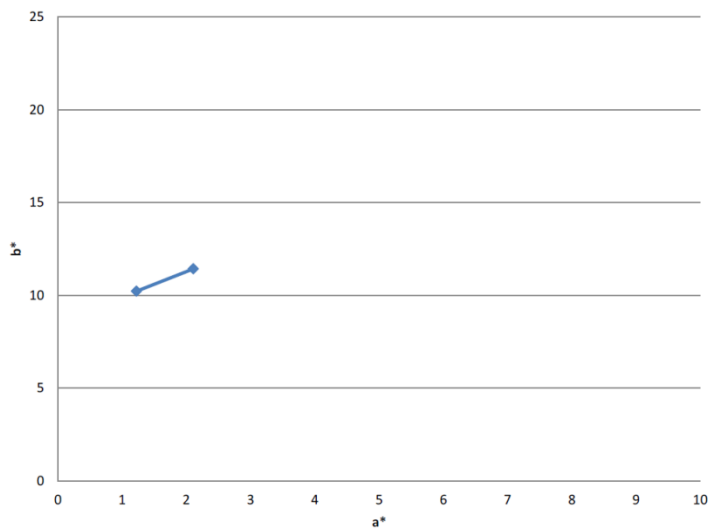
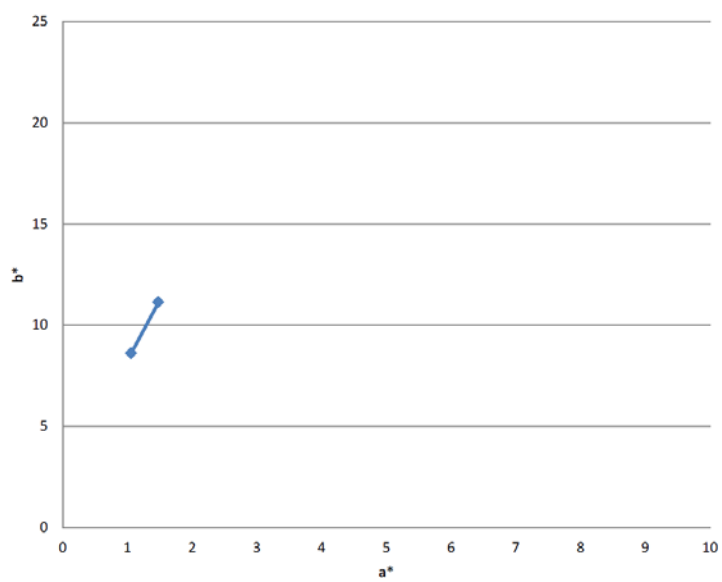


Figure 3-37. Quarter-Dollar MPPS Blank Color Change—Pre-Production Lot



CSV

The CSV tests showed acceptable conductivity, size, and EMS measurements for a co-circulate material, though the EMS was not unique among world coins, contributing to a security concern about the application of this material to the quarter-dollar. (The full test results are available in Appendix 10.6.2, at the end of this report.)

Hardness Test

The Mint tested two lots of 255 blank MPPS five-cent planchets and two lots of 255 blank MPPS quarter-dollar planchets for their hardness, using the Rockwell HR 15T scale. MPPS showed a hardness range of 65.4 to 69.9 with an average of 67.9 in the five-cent, and a range of 65.3 to 73.6 with an average of 68.8 in the quarter-dollar, almost identical to the hardness shown in the variability lots. The range of the samples showed a slightly harder level than the current cupronickel.

Wear Test

MPPS performed even better in the two-week wear test for pre-production than it had in variability. The five-cent and quarter-dollar nonsense pieces both lost an average of 3.4mg of the material compared with the 19.0mg lost by the current five-cent material and the 27.2mg lost by the current quarter-dollar material. Edge deformation in the five-cent and quarter-dollar MPPS was less than the deformation shown by the current material. (The full test results are available in Appendix 10.4.2.)

3.4.4. MPPS Down-Selection

Environmental Impact

Comparable or Better. As MPPS is a plated material being tested as a replacement for the monolithic five-cent and the three clad denominations, data suggests that the use of this material would have a negative impact on the waste stream. However, this impact could be effectively mitigated.

Supply Chain

Less than Current. All the raw materials in MPPS are in adequate supply, but the Royal Canadian Mint has a pending U.S. patent extension application on this material, effectively reducing the number of established suppliers to one, as compared to the current two suppliers for both the five-cent and the quarter-dollar.

Coinability

Less than Current. Pre-production strikes of standard-crown dies at comparable tonnage to the current strike force saw a significantly greater rate of failure to the dies than seen with

current materials. The Mint also observed inferior fill rates at comparable tonnage to the current material. More testing will be needed to see if these issues can be mitigated.

Recyclability

Less than Current. MPPS sees an inferior recycling option compared with current materials. While steel and nickel are both sought by stainless steel manufacturers, the inclusion of copper in this material limits its scrap market. Copper-bearing stainless steel grades made up only 40 percent and 15 percent at two domestic stainless steel plants, illustrating the limitations presented by the copper plating. The material is recyclable, for non-coin use only, but there is a potential land-fill issue with the volume of coins the Mint would likely recycle (based on the number of coins currently sent back to suppliers by the Mint).

Durability

Comparable or Better. The Mint observed a superior wear rate after the wear test and minimal discoloration after the steam test with MPPS. MPPS showed a wear rate 82 percent lower than the current material.

Counterfeit/Slug Vulnerability (Quarter-Dollar Only)

Less than Current. MPPS has a ferromagnetic core made of a very common material. The plating of this material is easily replicated and easily counterfeited (in testing, a steel slug plated for a few minutes in a copper solution (using only a battery) and another steel slug with aluminum foil taped to it were both accepted by two different coin acceptors as MPPS quarter-dollars). MPPS' EMS was also found to vary far more than the current quarter-dollar and was not unique among world coins. (The Philippine one-peso coin, for example, is approximately the same size as the quarter-dollar and is made of MPPS, but is only worth about $0.02.) The Mint determined that MPPS' security was lesser than the current quarter-dollar's.

Feasibility

Five-Cent – **Feasible**

Quarter-Dollar – **Not Feasible**

3.4.5. Nickel-Plated Steel (Pre-Production Lot)

Nickel-Plated Steel (NPS) rated as Comparable or Better for half of its Down Selection criteria as a co-circulate option for the five-cent and the quarter-dollar, but it rated as Less than Current in coinability, recyclability, and counterfeit/slug vulnerability (which did not apply to the five-cent).

After the variability testing was complete, the Mint provided feedback to The Royal Mint (RM) technical representatives and subsequently RM revised the upset profiles and sent small quantities of planchets (five-cent and quarter-dollar) called "Pilot lots." The RM also PVD-coated the dies to alleviate the abrasion of the blanks' nickel surface, but the Mint still observed a significantly greater rate of die failure than seen with the current material. Some die pairs were polished before PVD coating and others were not, to determine what difference, if any, polishing would make.

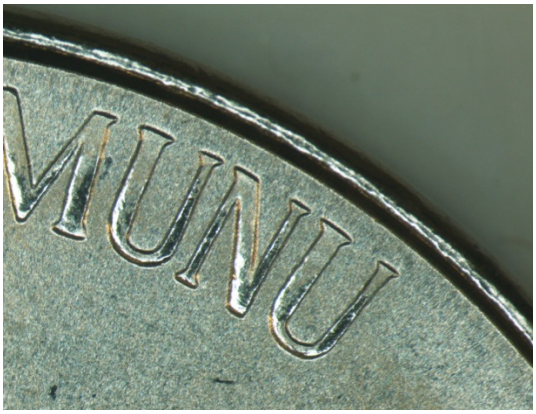
The Mint conducted further progression strikes, and quarter-dollar progression strikes demonstrated improvements from the previous strike, but required 66 tonnes to achieve acceptable design fill and coin dimensions. The border achieved fill at only 58 tonnes, which likely "locked" the metal at the border of the planchets, preventing the material in the center of the planchet from flowing out to the border and filling in the detail in the die.

Figure 3-38. NPS Quarter-Dollar Test Piece (66T Strike)

Revised-upset five-cent planchets produced test pieces with worse design fill and coin edge thickness than those of the previous progression strikes. Again, feedback was provided to RM for improvement to the five-cent upset profile prior to receiving pre-production quantities. Changes were also requested for the quarter-dollar to counter the die-failure rate.

The revised-upset quarter-dollar NPS planchets arrived in late July. In spite of the changes requested for the quarter-dollar planchets, design fill and coin edge thickness were still worse than those of the previous progression strikes. Die-life failure rates were also drastically higher with this material than with the current material. The data suggests that this material will continue to have issues with strike force and die-life failure regardless of changes made to the coining system.

Figure 3-39. NPS Five-Cent Test Piece (Detail)



NPS five-cent: edge lettering showing poor letter fill

Progression Strikes

After receiving the pre-production lots, the Mint struck five-cent NPS planchets at strike forces from 20 to 60 tonnes. The current five-cent tonnage is 54 tonnes, and at this and 56 tonnes, NPS fill was acceptable. The PVD coating on the dies succeeded in preventing abrasive wear scratches from appearing in struck pieces.

The Mint struck quarter-dollar NPS planchets at strike forces from 36 to 64 tonnes. The current quarter-dollar tonnage is 62 tonnes; design/border fill was acceptable at 55 tonnes, but the NPS nonsense pieces needed 64 tonnes to see acceptable fill in the lettering along the edge.

The rates of die failure with NPS were greater than that seen with the current material, as PVD-coated die pairs failed on an average of 261,000 strikes, below the baseline level of the current material and standard dies, which was 500,000. Dies that were not polished before PVD coating failed on an average of 77,000 strikes. Cracks presented on both the obverse (bonnet area) and reverse (building top corner to coin edge) of the dies.

The Mint determined the coating failures were related to metal oxides on the dies' surfaces. PVD coatings typically do not adhere as well to metal oxides as they do to elemental metal. The RM dies were relatively free of surface oxides after heat treatment and their follow-on polishing operation removed what thin oxide layer may have been present. U.S. Mint dies have much thicker oxide layers and limited post-finishing operation to remove these layers. The significant difference in die life seen between the non-polished and polished dies indicated that future dies would need to be polished to provide a more-uniform surface and one that was free of oxides.

The five-cent planchets and struck pieces further exhibited indications of poor lubrication, a condition that needs to be investigated further. The team saw unacceptable, excessive wear on the press parts, especially the press's mechanical "fingers" that move the planchets into position at the dies and the conveyor belts that take struck coins away. The excessive wear must be resolved to support sustained coining operations.

Improved coinability and die life could be achieved with an optimization of the die designs to be more compatible with the NPS material. The hardness check on the retained planchets showed NPS to be approximately 20 percent harder than the current material. Also, the upset profile of the planchets appeared sharper than the current material's flatter configuration. Both of these, along with the poor lubrication, could also have contributed to the excessive equipment wear.

While it is possible to double the die life with changes in coin features and lubrication, it is not likely that these changes alone will improve the die-life gap. Some reduction in die life is to be expected with this alternative material. The die life achieved by RM is around 600,000 strikes for the 5-pence and 10-pence coins. Other countries that RM has supplied with NPS have an average of 447,000 strikes with a range from 215,000 to 800,000. This average is on coins with differing features, and the quality standards for those mints are unknown. Given the need for coin changes and the lower anticipated die life, this material is considered as Less than Current for coinability and die wear.

Further research will be needed to determine what the optimized die life will be, but it is anticipated to be less than 500,000 strikes. A financial analysis can be performed on how the loss in productivity impacts the anticipated material cost savings.

Steam Test

There was little color change shown by the NPS blanks in the pre-production lot steam test, and the Mint determined NPS to be superior to the current five-cent and quarter-dollar materials for this test. The results are shown in Figures 3-40 and 3-41, below, with the "before" point lower and to the left of the "after" point in each graph. (The full test results are available in Appendix 10.5.1.)

Figure 3-40. Five-Cent NPS Blank Color Change—Pre-Production Lot

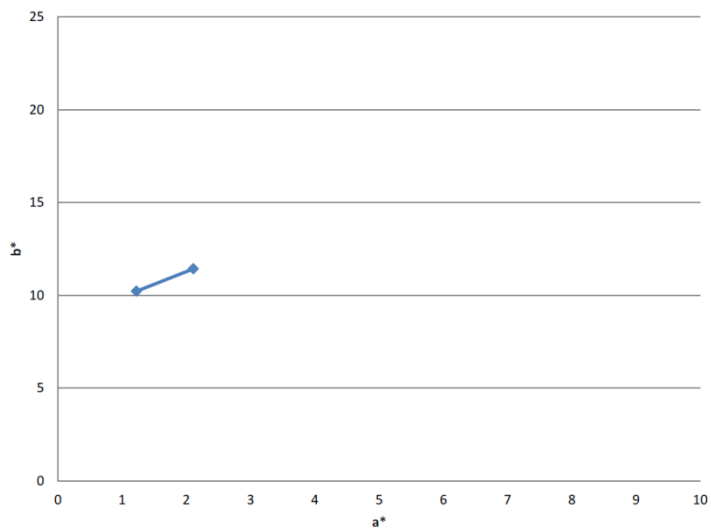
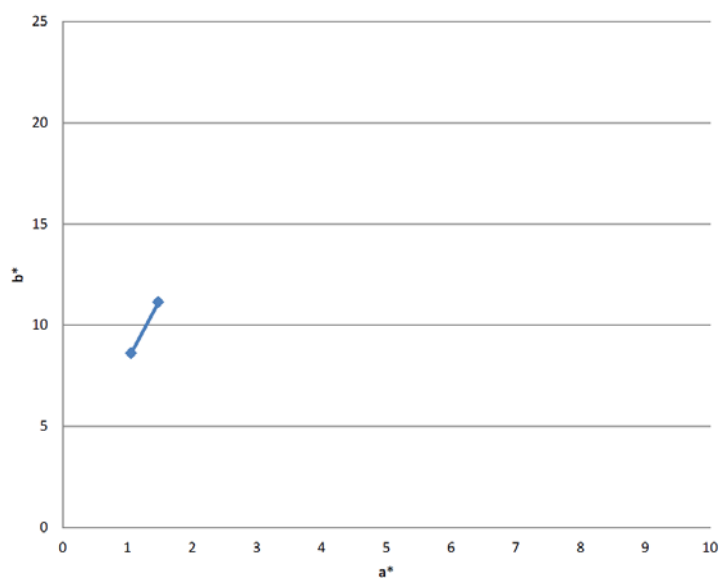


Figure 3-41. Quarter-Dollar NPS Blank Color Change—Pre-Production Lot



CSV

The CSV tests showed acceptable conductivity, size, and EMS measurements for a co-circulate material, though the EMS was not unique among world coins, contributing to this material's security failure for the quarter-dollar. (The full test results are available in Appendix 10.6.1.)

Hardness Test

The Mint tested two lots of 255 blank NPS five-cent planchets and two lots of 255 blank NPS quarter-dollar planchets for their hardness, using the Rockwell HR 15T scale. NPS showed a hardness range of 65.4 to 69.9 with an average of 67.9 in the five-cent, and a range of 65.3 to 73.6 with an average of 68.8 in the quarter-dollar, almost identical to the hardness seen in the variability lots. The range of the samples showed a higher hardness level than the current cupronickel.

Wear Test

As in the variability lot wear test, NPS performed exceptionally well, with a wear rate 72 percent lower than the current material (4.6mg v. 19mg for five-cent and 7.5mg v. 27.2mg for the quarter-dollar). In addition, the five-cent and the quarter-dollar NPS pieces showed an average edge deformation lower than that shown by the current material. (The full test results are available in Appendix 10.4.1.)

3.4.6. NPS Down-Selection

Environmental Impact

Comparable or Better. As NPS is a plated material being tested as a replacement for the monolithic five-cent and the three clad denominations, the data suggests that the use of NPS would have a negative impact on the waste stream. However, that impact could be effectively mitigated.

Supply Chain

Comparable or Better. All the raw materials in NPS are in adequate supply. There are at least two established suppliers, which is identical to the current two suppliers for both the five-cent and the quarter-dollar.

Coinability

Less than Current. Pre-production strikes of standard-crown dies at comparable tonnage to the current material had a significantly greater rate of die failure than with current materials. The Mint also observed that changes The Royal Mint made to the upset profile between the Pilot lot and the pre-production lot improved the fill on progression strikes dramatically.

The Mint also saw more wear on the press machinery, from the feed bowl, the mechanical "fingers" that move planchets into the press, and the conveyor belt that carries the new coins away. In some of these cases, parts that normally would last weeks required changing every eight hours or less.

Recyclability

Less than Current. NPS sees an inferior recycling option compared with current materials. While steel and nickel are both sought by stainless steel manufacturers, the recyclability would be for non-coin use only.

Durability

Comparable or Better. The Mint observed a superior wear rate and minimal discoloration with NPS. NPS showed a wear rate of only 18 percent, below the maximum 20 percent set by the Mint.

Counterfeit/Slug Vulnerability (Quarter-Dollar Only)

Lesser than Current. NPS has a ferromagnetic core and is made of commonly used, readily available materials. NPS' plating is easily replicated (many web sites have simple instructions on how to nickel-plate objects such as coins). The EMS was wider than the current quarter-dollar and was not unique among world coins. (The Nigerian 50-Kobo coin, for example, is approximately the same size as the quarter-dollar and is made of NPS, but is only worth $0.003.) The Mint determined that NPS' security was lesser than the current quarter-dollar's.

Feasibility

Five-Cent – **Feasible**

Quarter-Dollar – **Not Feasible**

3.4.7. Cupronickel 80/20B (Pre-Production Lot)

Cupronickel 80/20 supplied by Supplier B (80/20B) rated as Comparable or Better for all of its Down Selection criteria as a seamless option for the five-cent, and is expected to perform equally well as cladding for the dime, quarter-dollar, and half-dollar (testing to begin in Phase III).

Progression Strikes

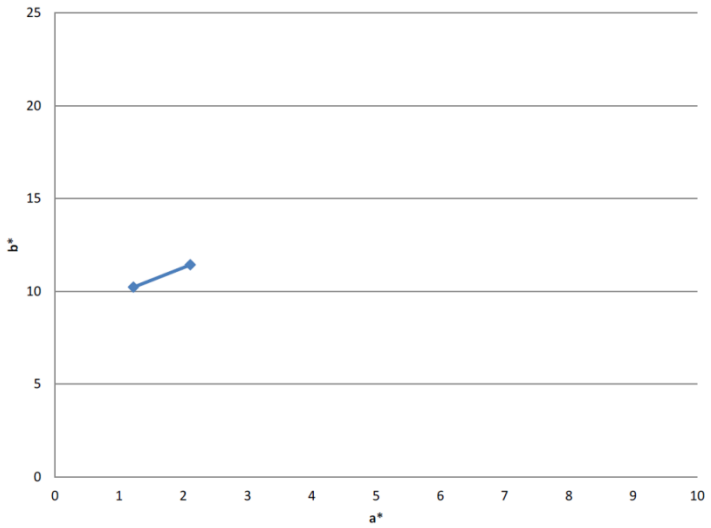
The Mint struck five-cent 80/20B planchets at strike forces from 20 to 60 tonnes. The current five-cent tonnage is 54 tonnes, and at this and 56 tonnes, 80/20B fill was acceptable.

Figure 3-44. 80/20B Test Piece (54T Strike)

Steam Test

There was little color change shown by the 80/20B blanks in the pre-production lot steam test, and the Mint determined 80/20B to be comparable to the current five-cent material for this test. The results are shown in Figure 3-43, below, with the "before" point lower and to the left of the "after" point in the graph. (The full test results are available in Appendix 10.5.3.)

Figure 3-45. Five-Cent 80/20Blank Color Change—Pre-Production Lot



CSV

The CSV tests showed acceptable size measurements for a seamless material, and an EMS that matched the current five-cent. (The full test results are available in Appendix 10.6.3.)

Hardness Test

The Mint tested two lots of 255 blank 80/20B five-cent planchets, using the Rockwell HR 15T scale. 80/20B showed a hardness range of 65.4 to 69.9 with an average of 67.9 in the five-cent, almost identical to the current cupronickel.

Conductivity

The Mint tested six batches of five random 80/20B planchets for their conductivity. The planchets were tested at four different frequencies, and from the lowest to the highest frequencies, 80/20B yielded IACS readings of 5.61% to 6.93%. Deviations among the pieces tested at each frequency were well within acceptable parameters. The readings were very similar to current conductivity measurements.

Wear Test

As in the variability lot wear test, 80/20B wear rate was comparable to the current material, losing 7 percent less material (17.6mg v. 19mg). In addition, the five-cent pieces showed an average edge deformation lower than that shown by the current material. (The full test results are available in Appendix 10.4.3.)

3.4.8. 80/20B Down-Selection

Environmental Impact

Comparable or Better. 80/20B has nearly the same configuration as the current five-cent, and the addition of manganese does not cause any significant environmental impact.

Supply Chain

Comparable or Better. All the raw materials in 80/20B are in adequate supply. The number of established suppliers is identical to the current two suppliers for the five-cent.

Coinability

Comparable or Better. Pre-production strikes of standard-crown dies at comparable tonnage to the current strike force saw a slightly lesser rate of failure to the dies than seen with current materials. The Mint also observed acceptable fill rates at comparable tonnage to the current material.

Recyclability

Comparable or Better. 80/20B sees a comparable recycling option compared with current materials for the five-cent. If this material is also chosen to replace the cladding in the clad denominations, then the inclusion of manganese may impact the recycling options.

Durability

Comparable or Better. The Mint observed a comparable wear rate and minimal discoloration with 80/20B. 80/20B showed a wear rate of only 18 percent, below the maximum 20 percent set by the Mint.

Counterfeit/Slug Vulnerability (Quarter-Dollar Only)

Comparable or Better. If 80/20B is chosen to replace the cladding on U.S. clad coins, its unique EMS will combine with the clad configuration to provide a similar level of security as that found in the current materials.

Feasibility

Five-Cent – **Feasible**

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4. U.S. Coin Security

4.1. Threats

In coinage, there are two threats: counterfeiting and fraud. Both can create problems for vendors and shop owners, as well as public mistrust in coins.

4.1.1. Counterfeiting

Counterfeit coins are imitations that are passed off fraudulently or deceptively as genuine coins. In practice, they are easily rejected by mechanical coin validators as the EMS is incorrect, but in person-to-person commerce, they can be easily mistaken for genuine coinage. The fake coin is almost always of little or no value.

Sometimes, coins from other countries, which look similar to U.S. coins, enter circulation. Canadian quarter-dollars are one example. This becomes problematic when legitimate coins (with a low value) from one country are accepted in another country as a higher-value coin. In 2006, the Philippine 1-peso (value of 2.4 U.S. cents) was discovered to be passing for the 1-dirham coin in the United Arab Emirates (value of 27.2 U.S. cents).[29] In another case in 2013, Amsterdam discovered that over 10,000 Thailand 10-baht coins (value of 23 euro cents) had been passing for 2-euro coins in that city alone.[30]

4.1.2. Fraud

Fraud involves deceitfully and purposefully replacing coinage with slugs or tokens that are accepted by mechanical coin validators as genuine. Mechanical coin acceptors rely on dimensions and electromagnetic signature (EMS) rather than visual recognition. In a fraudulent scenario, the readout of the fake coin matches a genuine coin, but it may not have the same appearance. The fraud is recognized after the fact when the vending machine is serviced, but by then it is too late to prevent the theft. As with counterfeit coins, fraudulent tokens are usually of little or no value. In 2004, a man in Atlanta was arrested and convicted for defrauding the U.S. Postal Service (USPS) with 150,000 fake dimes he had made and used in USPS stamp machines over the course of several weeks.[31]

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[29] Source: http://gulfnews.com/news/gulf/uae/general/hey-presto-a-peso-s-as-good-as-a-dirham-1.38628 (Aug. 1, 2006)

[30] Source: http://www.dutchamsterdam.nl/2375-amsterdam-flooded-with-thai-currency (Dec. 11, 2013)

[31] Source: internal communication between the defrauded Atlanta Post Office and the U.S. Mint HQ (2004-2006).

Figure 4-1. Slugs and Tokens

U.S. quarter-dollar above slugs and tokens collected from vending machines

The absence of a cashier to visually authenticate a coin enables an individual (commonly called a "fraudster") to substitute lower-value foreign coins or other non-genuine items (tokens or slugs) without risk. Given the anonymous nature of vending transactions, fraud is a very real concern with coin design and materials.

4.2. Security Features of U.S. Coinage

Coin security is based on overt and covert features. Overt features are those easily determined through visual or quick dimensional or weight check. A cashier would look at the coin to determine if it looks (design and color), feels (weight), and sounds like a real coin when deposited into the cash register. A vending machine would check the diameter or thickness and possibly the weight. Covert features, which cannot be easily validated visually, rely on material composition or makeup. Measurement of covert features is done through electrical circuitry or other instrumentation. As coins increase in value, more covert features are incorporated to deter fraud.

4.2.1. Background

Vending equipment facilitates commercial transactions without a human to handle and validate the payment. The coin acceptor mechanism that validates the authenticity of the payment is called a discriminator. Vending equipment prior to 1963 contained rudimentary discriminators based primarily on the physical attributes of the coinage, (size, density, weight, etc.).

Common construction items like washers and conduit knockouts could be modified to trick these rudimentary discriminators; thus, magnets were incorporated in vending equipment to reject steel-based materials. As product costs in vending machines increased, industry required improved methods, and discriminators needed more sophistication and complexity. The application of miniaturization, electronic transducers, and sensing technology created an opportunity to take coin validation to the next level in vending. Such technology led to the development of systems to detect a coin's EMS or conductivity, both of which can uniquely identify a particular coin type.

Vending discriminators now vary in complexity, depending on the value of the product served or service rendered. For example, a "canteen operation," where product values often exceed one dollar, allows bills, coins, and sometimes stored-value or credit card transactions. The coin discriminators in this system will employ more advanced features. In contrast, a laundromat, car wash or other low-value product/service vending application relies on overt coin characteristics and may only contain a physical check of the coin (thickness and diameter).

4.2.2. Variances in Conductivity/EMS

Conductivity is the percent IACS (International Annealed Copper Standard) for non-ferrous alloys (see section 3.2.7). It is a ratio of a particular alloy's conductivity compared to pure copper at 20 degrees Celsius. EMS is a measure of a material as an "eddy current" is passed through it, providing unique values for various metallic compositions. Both EMS and conductivity are measured at various frequencies. Unfortunately, there is no established industry standard for what frequency to use and conductivity/EMS readings on materials differ from frequency to frequency. This means two materials' readings may match at one frequency, but be different at another.

The lack of a standard frequency creates challenges in identifying a material that can display the same EMS across the range of frequencies used in coin acceptors. For ferromagnetic products, an additional property (material permeability) also impacts the EMS. Other components of coin acceptor discriminators relate to coins' physical dimensions, specifically, inductive thickness, an electrical reading based on the actual thickness of a specific alloy.

Vending discriminators must also accept a range of coin properties and conditions but also screen out foreign coins, tokens, and slugs. However, the physical properties of coins can vary based on age, use, and manufacturing tolerances. Coins with more wear have less material and this affects the coins' measurements. A coin that is used, for example, in

vending or casino operations will see more physical wear than one that is cycled through the banking system or a coin that sits in a consumer's jar for years. A tolerance band is set up for the various properties being measured and periodically adjusted to accommodate the coins in circulation. Many coin acceptors can be adjusted through software or a programming service call, but older ones still require physical modification. A change in composition or physical dimensions will affect the various vending segments differently and the impact will be immediately felt by industry.

4.2.3. Coin Construction

Up to 1964, U.S. coinage for the dime and higher denominations were 90 percent silver. As silver supplies dwindled and metal costs rose, the U.S. government changed the metal composition. The new coinage material consisted of a pure copper core with a silver-colored nickel/copper alloy skin. The skin was applied to the core through a mechanical process called cladding in which the different materials were rolled and reduced in thickness under pressure, bonding the materials together. The Mint punches coin blanks or planchets from sheets of clad material and presses (cold forms or "coins") the planchets into coins with the appropriate dies. The result are clad coins with multiple layers.

By applying different signals through the sensing circuits in the coin acceptor discriminator, sensors can see through the cladding layer and detect the core composition yielding two separate and distinct signals for use in discrimination. Thus, the new clad material provided increased security in coinage, both from the physical dimensions (diameter and thickness) and from the metallic composition (skin and core metallic makeup).

The rising cost of raw materials is creating a challenge for world mints, driving them to use lower-cost metals. Sensitive to the needs of commerce (banking and vending), national governments must weigh the benefit of making the material change versus the impact to industry. Some have gravitated to using iron or steel as a substrate which complicates the security of discriminators in vending equipment. Magnets, which were used to screen out common items, cannot be used if coins themselves are ferromagnetic. Also, due to the abundance of steel items that can be modified to fit into vending equipment (conduit knockouts, washers, etc.), steel is considered to present a higher level of fraud in vending. As such, most countries consider steel viable for use in low-value coinage only.

4.2.4. Coin Security Evolution

As world mints evolve and introduce higher-value coinage systems, fraud potential increases, and more sophisticated security systems are necessary to deter fraudsters. New technologies

are being developed by, or in conjunction with, world mints incorporating acoustical, optical or micro-text signatures. These technologies are generally proprietary and are just being considered for use in major coinage systems.

For example, The Royal Mint has developed and patented a technology termed "iSIS." The technology is based on introducing a fluoroluminescent compound into the plated layer that is detected by a proprietary sensor. The measured density of the compound particles is used to validate the coin. Another advanced technology developed by the Mint of Finland is called "CoinTune." This proprietary technology is based on developing a unique acoustical signature of a coin and subsequently reading this signature in vending to validate the coin. Finally, the Royal Canadian Mint has developed a micro-text/engraving process that provides a unique and difficult to reproduce optical signature on the coin face. It also has developed what it terms "DNA Mapping," which maps and stores the unique morphology on a specific location of the coin surface for future reference and validation. This "signature" is unique on each coin produced and enables RM to verify or authenticate the coin.

The viability of incorporating such technologies into vending equipment has yet to be quantified and is subject to factors such as cost, complexity, and maintenance requirements. In discussions with various coin acceptor manufacturers, there is no active program to incorporate any of these new technologies into existing coin acceptors. With time to be allotted for design, marketing, and transition by the vending industry, this would place any change in the sensor base on a five-year or greater horizon. Until such a time that these new technologies are proven cost-effective and reliable in application, the electromagnetic signature of clad and non-ferrous materials represents the security benchmark for coinage alloys in automated vending operations.

4.3. Steel-Based Coin Security

During the course of Phase II, the Mint worked closely with several, large coin acceptor manufacturers—Cummins Allison, MEI, SCAN COIN and Coinstar—to test and analyze struck pieces. The Mint also communicated with U.S.-based manufacturer CoinCo and obtained its feedback.[32] These are the main companies that produce the coin-accepting mechanisms used in vending machines within the United States and worldwide.

[32] CoinCo tested materials in Phase I, but did not have the available time or resources to support testing in Phase II.

As a primary reference document, the Mint used The Coin Design Handbook, version 2 (2012) prepared by the European Vending Association (EVA).[33] This document was written by the following EVA member companies: CoinCo, MEI Conlux, NGZ, NRI (part of Crane Payment Solutions), and SCAN COIN. In addition, it was endorsed by a number of the EVA Coin Group member companies including Cummins Allison. Given the extensive international involvement, it was considered a valuable reference document in evaluating coin materials and designs for both compatibility with coin accepting mechanisms and also security.

In the Handbook, the EVA defines Security as, "A coin that does not **misvalidate**, is able to be **differentiated** correctly, is not **easy** to **fraud**, and has a low **fraud** risk, is regarded as being more secure and suitable for higher value coins."[34] Key considerations include the similarity to other, lesser-valued, world coins and the ease of creating fraudulent coins, including knowledge of techniques, and availability of equipment and materials. Complex machining, unique or expensive equipment, and materials that are more difficult to obtain provide increased protection against fraud. According to the EVA, "Fraud coins that are very simple to manufacture and use widely available materials can present a very real **fraud risk** to relatively low value **coins**."[34]

The EVA further defines coins by their value using the Euro as the basis. Coins are characterized in Table 4-1, below.

Table 4-1. EVA Coin Value Categories

Category	Value
Very Low Value	up to 2 cents Euro or equivalent (up to approx. 2.7¢ U.S.)[35]
Low Value	>2 cents Euro to 20 cent Euro or equivalent (>2.7¢ to approx. 27¢ U.S.)
Medium Value	>20 cents Euro to 50 cents Euro or equivalent (>27¢ to approx. 68¢ U.S.)
High Value	>50 cents Euro or equivalent (>68¢ U.S.)

[33] Previously known as the World Vending Association, founded by the U.S.-based National Automatic Merchandising Association and the EVA.
[34] Emphasis EVA's.
[35] Using an exchange rate of 1 Euro = $ 1.357.

The level of a coin's security is directly related to its value. Stated differently, the level of security (and cost associated) should be commensurate with the coins value to effectively support commerce. Fraudsters and counterfeiters are drawn to higher-value coins, with a greater return for their effort.

Steel-based coinage materials considered in Phase II include plated steel and stainless steel. The Mint tested plated steel in two versions: nickel-plated steel obtained from The Royal Mint and multi-ply-plated steel obtained from the Royal Canadian Mint. These are single or multiple layers of nickel and copper/nickel plated on a cold-rolled, low-carbon steel core. They are used in coinage worldwide. The Mint worked with an external research firm to test different grades of stainless steel.

4.3.1. Plated Steel

When discussing coin security vs. construction, the EVA Handbook notes:

Single Layer (i.e. Nickel-Plated Steel)

> *Plated coins that have a single plated layer on a solid steel core are effected by the variability in the manufacturing process and the dominant effects of the core.* (page 28)
>
> *The risk from fraud is high due to the ready availability of round steel discs. As well as widespread availability of Copper and Nickel plating facilities worldwide.* (page 28)
>
> *Single layer plated coins should only be used for low value coins because of the ease of and risk from fraud.* (page 28)

Multi-Layer Plated Coins

> *The risk from fraud is high due to the ready availability of round steel discs. As well as widespread availability of Copper and Nickel plating facilities worldwide.* (page 30)
>
> *Although multilayer plated coins enable other single layer plated steel coins that have a similar diameter and thickness to be differentiated, they have a high risk from fraud because of their steel and copper/nickel plated construction. Overall they offer no improvements in security using inductive material sensors in today's coin validators when compared to single plated layer.* (page 30)

Multilayer plated coins should only be used for low value coins because of the ease of and risk from fraud. (page 30)

Ferromagnetism

Steel is ferromagnetic (attracted by a magnet), which presents several problems in coin acceptor security. Phase I identified vending machines and laundromat facilities as being the dominant shareholders for automated point-of-sale transactions. These machines have a magnetic discriminator intended to capture steel slugs, which would need to be removed or disabled to accommodate steel coins.

Foreign Coins

Although plated-steel coins would cost less to produce, they are also more vulnerable to fraud. Several examples of foreign plated-steel coins show the relationship between construction, coin value, the EVA guidelines, and equivalent U.S. values.

Table 4-2. Foreign Plated-Steel Coins

Country/Region	Denominations	EVA Coin Value	U.S. Equivalent
Canada	5-cent	low value	4.6 cents
	10-cent	low value	9.2 cents
	25-cent	low value	23 cents
	50-cent	medium value	46 cents
	1-dollar	high value	92 cents
	2-dollar	high value	184 cents
United Kingdom	5-pence	low value	8.5 cents
	10-pence	low value	17 cents
	Note: 20-pence through 1-pound are monolithic alloy construction (non-steel). Higher is non-steel bi-metallic.		
European Union	1-cent	very low value	1.36 cents
	2-cent	very low value	2.74 cents
	5-cent	low value	6.8 cents
	Note: 10-cent through 50-cent are monolithic alloy construction (non-steel). Higher are non-steel bi-metallic.		

The majority of mints conform to the EVA guidelines and only use plated coins for low-value denominations (i.e., below approximately 27¢ U.S.). The Royal Canadian Mint, however, utilizes plated materials for low-, medium- and high-value denominations. In separate discussions, neither The Royal Mint nor the Royal Canadian Mint claims to experience fraud with their plated coins, though the RCM employs many security features (such as laser-etching a micro-engraved image of a maple leaf on their one-dollar coin). The Royal Canadian Mint and The Royal Mint (as well as other international mints) also have

active research programs in anti-fraud techniques to improve the security of their plated-steel coins.

While the UK and Canada claim not to experience significant counterfeiting with their plated-steel coins, many examples of counterfeiting are reported in China, which uses nickel-plated steel coins. In 1991, China began to use nickel-plated steel on its one-Yuan coins. The core is low-carbon steel and surface is plated with pure nickel. Because the common core materials cost very little, and nickel plating is an inexpensive, simple process, there have been tens of millions of counterfeit one-Yuan coins circulating since the coins' release. The total cost for making a single, fake, one-Yuan coin is about 3 U.S. cents.

The following table shows a partial list of seized counterfeit one-Yuan coins; these were published in Chinese newspapers. More counterfeit coins are still circulating, and as a result, many small shops in China no longer accept one-Yuan coins in commerce.

Table 4-3. Counterfeit Seizures in China

Date	Location	Quantity
2006 May	Nanchang	10,000,000
2006 August	Heibei Province	10,520,000
2007 December	Nanjin	30,000,000
2008 November	Fuzhou	700,000
2009 August	Feishan	220,000
2009 August	Zhengzhou	100,000
2009 September	Hefei	1,000,000

4.3.2. Stainless Steel

Stainless steel is being considered as an alternative metal for U.S. coinage. It is termed monolithic or homogeneous since it consists solely of one alloy and exhibits the same chemical composition throughout. Stainless steel is produced in two forms: ferritic (400 series) and austenitic (200 and 300 series), both of which are an alloy of iron and chromium.

Ferritic stainless steel has very little nickel and therefore has lower material costs. It is ferromagnetic, which means it is attracted by a magnet. This presents several problems in vending security. First, many coin acceptors used in vending and the laundromat industry

have a magnetic discriminator intended to capture steel slugs; this would need to be removed or disabled to accommodate ferritic steel coins. Second, the ferritic steel's EMS is highly variable and influenced by manufacturing inconsistencies and by the handling of a coin over time. This requires coin acceptors to undergo modifications to have a wider acceptance band, making the material less secure when used in coin validators.

Austenitic stainless steel has a significant quantity of nickel (which makes it non-ferromagnetic), so it has a higher material cost. The EMS of austenitic steel does not vary much from alloy to alloy, though, which means a coin validator cannot effectively discriminate between one austenitic stainless steel grade and another.

4.3.3. Homogeneous Materials

For both ferritic and austenitic stainless steels, the EVA Handbook notes that:

> *Non-magnetic homogeneous coins are generally to be considered for low to medium value denominations; however the security of the coin depends significantly on the choice of material.*

If the homogeneous material is commonly available and/or cheap, the risk of fraud is greater because there is no unique construction in homogeneous coins or special EMS to help discriminate real coins from frauds. Stainless steel's readily available material and solid construction enables someone to easily manufacture a disc that could be used in vending. For low-value coins, this is not a significant risk as the return on investment does not offset the fraudster's time and costs in manufacturing the fakes. Risk becomes greater at higher denominations, where there is more return on investment.

4.3.4. Coin Sorter/Validator Testing

Although each coin acceptor manufacturer has a different algorithm and frequency in their mechanisms, each measures the conductivity of coins. The "accept" range of these mechanisms' sensors (the "band width," or "window") is of particular concern in coin security. If two compositions of the same coin/denomination have very different EMSs, the mechanism needs to be set to accept both, which means its window of acceptance opens very wide, leaving it more vulnerable to being defrauded by slugs and tokens that could easily fall inside the window.

The Mint used an industry-standard coin sorter/validator (CSV) to capture data of various materials being tested and considered. The Mint compared the internal test results of various

materials which compared the spread in both the Outer Conductivity (OC) and Inner Conductivity (IC).

The CSV sensors change their frequency to read the coin only partially under the surface, and then read the same coin more deeply, to gather the entire EMS of the material. As coins pass through, some variability is seen. In testing, for the current cupronickel, the sensor readings and their variability was recorded, giving an average value for each of the criteria with the variance on each criterion.

The CSV was programmed with acceptance windows pre-set for each EMS parameter. The acceptance window width was based on the variance of actual coins, either newly minted or pulled from circulating coinage. The Mint's coin validation involved comparing the measured value of each EMS parameter to the acceptance windows for coin validation.

The plated-steel materials' criteria for the five-cent pieces differed drastically from the current material, having some scores 12 percent higher, and others over 50 percent lower than the current material. Most of the criteria had a variance at least 10 percent higher than the average score. For inner and outer conductivity, the variance for NPS and MPPS was over 33 percent of the average score, as compared with just over 10 percent variance on the current material.

The Mint made the following findings from this test:

1. Plated-steel EMS ranges are wider than those of the current material, necessitating wider acceptance windows and therefore less security.
2. Plated-steel and monolithic EMS ranges tend to overlap at multiple frequencies, diminishing the enhanced security of dual-frequency coin validation.
3. Clad construction offers high security, as evidenced by the low incidence of EMS overlap with MPPS and NPS. These findings are in line with EVA's Coin Design Handbook's rating of clad construction being more secure than plated.
4. Clad constructions may have relatively large EMS range widths, but security is not compromised because EMS average values are widely separated when validated using dual-frequency acceptors.

The complete readings are available in Appendix 10.9.

4.4. Steel-Based Coin Security Conclusions

Given the EVA guidelines, it is clear that steel coin construction would present acceptable risks for application on the United States five-cent and dime (low-value denominations). While the quarter-dollar is technically below the EVA-recommended threshold, it is very close, and that status is sensitive to variations in the exchange rate (since the EVA guidelines are based on the Euro). Of greater consideration in the United States is the fact that the quarter-dollar is the highest-value coin used regularly in vending transactions. This means that the risk of fraud on this denomination needs to be seriously considered in this country more so than others. While ultimately a policy decision (risk vs. return), the application of plated-steel material to the quarter-dollar is not advisable from a technical perspective. The material gains must be weighed against the impact of fraud and its effect on the confidence of the monetary system in supporting commerce.

Use of stainless steel for the five-cent or the dime (not both) would be acceptable from a security standpoint; use of stainless steel would not be acceptable for the quarter-dollar. One unique consideration with homogeneous coin construction is the relative size of the denominations. In most of the world's coin sets, the size of the coin increases as the value does. This means a lower-valued coin could not be made into a higher-valued one by rolling or resizing. In the U.S., the larger size of the five-cent vs. the dime (a legacy of the relative value of cupronickel vs. silver) would allow this practice, and so precludes the use of the same monolithic material on both the five-cent and the dime.

5. Coinability

Coinability is a subjective characteristic, but a critical one when evaluating potential materials for coining. It is the term associated with how readily a material can be struck into a coin and encompasses a number of elements including material mechanical properties, blank preparation/lubrication, upset profile[36], level of details in the coin design, height of details in the design (i.e. height of relief[37] and crown[38]), and die surface finish. Each of these elements contributes in varying degrees to the performance of a material during high-speed stamping. Throughout testing, the Mint expended significant effort to keep these elements consistent from material to material.

When evaluating a potential material, a balance must be achieved between keeping the elements consistent with other material testing (to attribute the outcome to the alternative material) and optimizing the above elements for each material (as they act as a "system" coming together to produce a result). For the purposes of consistency, the main focus was on using the same die design, stamping press, and quality standard.

5.1. Testing Methods

Two methods were used to evaluate coinability: progressions strikes[39] and extended striking trials (pre-production runs) in which die pairs were run to failure. Acceptable quality was determined through initial progression strikes on the material in which coin fill and dimensions were evaluated with increasing striking force and an aim striking tonnage set that provided acceptable visual and dimensional results.

Over the course of pre-production runs, the dimensions and appearance of the struck pieces were checked frequently with the quality standards being the same as those used in normal production operations for circulating coins. Circulating coins are not free from defects, but the coins must be within dimensional tolerances and observed defects must be limited in

[36] Upset refers to movement of metal on the edge to pre-form the rim.
[37] Height of relief is dimension of highest part of the artwork as referenced from the lowest part of the field adjacent to the artwork.
[38] Crown is the dimension that characterizes the depth of the basin before the artwork is overlaid.
[39] Progression strikes are a controlled test where the striking force is incrementally increased and the development of the design fill, edge profile, and coin dimensions are closely examined to evaluate a material. In addition, an aim striking force (tonnage) is established that provides an acceptable level of visual quality and dimensional compliance.

size. The resultant average for die life and the level/degree of defects observed in the die and struck piece were the basis for determining coinability. A rating of Comparable or Better (than the current material) or Less than Current was determined and used as one of the down-select criteria.

The Martha Washington nonsense design was patterned exactly after the current designs used for circulating coins with similar images (Martha Washington instead of Thomas Jefferson on the five-cent or George Washington on the quarter-dollar obverse and Mount Vernon vs. Monticello on the reverse of the five-cent) and similar inscriptions (same letters, but jumbled). As it was known that U.S. coin designs have more detail and relief than most circulating world coins, two alternatives were developed to the standard-crown nonsense dies. These were half-crown and flat-crown in which the nonsense design details were kept identical, but the height of relief and crown were reduced by half (half-crown) and then again by half (flat-crown) to provide dies that more closely approximated international coinage. Pre-production runs were performed on the current material for both the standard and the modified dies so there would be a valid baseline.

5.2. Baseline Results

Obtaining a statistically valid die life for alternative materials would require a significant number of runs. To evaluate coinability on candidate materials, the Mint decided to run at least four die pairs to failure or 500,000 strikes, whichever came first. A target of 500,000 strikes was established because that represented an acceptable productivity threshold for die life and was representative of past results on the five-cent and quarter-dollar circulating coins (see section 1.5).

Tables 5-1 and 5-2, below, respectively show the results of the baseline run on the current five-cent and quarter-dollar materials. Each die pair consisted of an obverse die and a reverse die. If one die in a pair failed, both were then replaced.

Table 5-1. Baseline Die-Life Determination (Five-Cent)

Die Pair	Crown	Die Life (strikes)	Failure Mode
1st	Standard	365,672	Crack and piece out on reverse
2nd	Standard	500,003	No objectionable defects
3rd	Standard	500,031	Crack observed on bonnet and weakness in steps on reverse; was borderline to continue
4th	Standard	641,116	No objectionable defects ran until 641,116 and retired dies
5th	Half	500,000	No objectionable defects noted
6th	Half	500,003	Slight crack developing at top of bonnet
7th	Half	500,350	No objectionable defects noted
8th	Half	503,256	No objectionable defects noted
9th	Flat	500,037	No objectionable defects noted
10th	Flat	458,247	Piece out noted on reverse before 200,000, not significant enough to pull the die. 2nd piece out noted on reverse still acceptable for circulating quality. 3rd piece out observed and dies pulled.
11th	Flat	500,126	No objectionable defects noted
12th	Flat	467,655	Piece out noted on reverse (letter S)
Overall		5,936,496	Average 494,708

These results validated that the Martha Washington nonsense dies were representative of the normal circulating dies in that they displayed similar defect patterns and life.

The results of the baseline run on current quarter-dollar material with half- and standard-crown dies are in the following table.

Table 5-2. Baseline Die-Life Determination (Quarter-Dollar)

Die Pair	Crown	Die Life (strikes)	Failure Mode
1st	Standard	500,028	No objectionable defects noted
2nd	Standard	500,004	No objectionable defects noted
3rd	Standard	459,075	Crack on obverse near base of Martha's bust
4th	Standard	500,002	No objectionable defects noted
5th	Half	500,000	No objectionable defects noted
6th	Half	501,856	No objectionable defects noted
7th	Half	500,000	No objectionable defects noted
8th	Half	311,601*	Defect noted on obverse, die retired. Under further examination, "defect" was an impression from debris stamped into the surface; no actual defect in die.
Overall		3,460,965	Average 494,424

* - Die retired prematurely; not counted toward overall or average.

Again, the results both validated the use of the Martha Washington nonsense dies as representative of circulating results and the use of 500,000 as a target threshold.

5.2.1. 80/20B Five-Cent

The upset profile on the material provided for the pre-production run was similar to that used for the circulating five-cent. Procedures for annealing and blank preparation (including chemicals currently used) were provided to the vendor. The Mint does not have any large capacity capability for annealing or preparing blanks without risking contamination with current material, so external processing was necessary. Progression strikes set aim tonnage at 54 tonnes.

Table 5-3. Initial 80/20B Die Life (Five-Cent)

Die Pair	Die Life (strikes)	Failure Mode
1st	<100,000, but ran to 500,000	Significant wear noticed on both sides before 20,000, would have retired before 100,000 but continued run to 500,000. Engraver initials worn on the obverse around 200,000. Cracks noticed in the bonnet area around 400,000 strikes. Cracking more prevalent, especially on the obverse letters.
2nd	<100,000, but ran to 255,274	Wear noticed on reverse starting at 12,000 strikes. Cracking noticed in the bonnet area around 200,000 strikes. Excessive die wear seen, but elected to continue to observe other defects.
3rd	67,413	Wear observed on outer perimeter of struck piece by 10,000 strikes. Noticeable wear at 20,000 strikes on both sides. Wear marks developing near nose on the obverse at 40,000. Dies retired when wear was deemed excessive visually.
4th	116,130	Same pattern of wear developing by 20,000 strikes including the nose area. Retired dies due to excessive wear.
5th	64,574+	Material burnished using standard circulating chemicals. Ran available material, no noticeable wear and die pair could have been run much longer.
Overall	1,005,391 (603,391)	Average 120,678

The 80/20 material is very close in composition to the current cupronickel (75% copper, 25% nickel). There is a larger quantity of manganese in the 80/20 to match the EMS of the five-cent, approximately 4% Mn vs. less than 0.6% in the current material. The manganese level is similar to the level in the dollar coin material which does not exhibit excessive die wear, so the difference in manganese is not felt to be a contributor to the excessive die wear. Given that, the material's performance was not considered representative. The Mint associated the premature wear issue with the blank cleaning/lubrication being significantly different than that on our standard cupronickel.

On a conference call with the supplier, the Mint learned the desired lubricant chemical had not been applied and, in fact, there was only a tarnish inhibitor applied to the blanks, no lubrication. This was confirmed when a small quantity of the 80/20B blanks were burnished in the small-volume burnishing machine in the R&D room. The Mint then struck the newly burnished material with normal appearance through over 60,000 strikes (see 5th die pair in

Table 5-3, above). Wear had been noticed consistently before 20,000 strikes on the untreated material.

Coinability and die life of the 80/20B cannot be definitively assessed on these results. The excessive die wear is considered to be related to the inadequate blank preparation, specifically no lubrication. The remaining material was returned for proper blank preparation and the pre-production run resumed on July 14, 2014.

Testing resumed when the Mint received the treated material. There were some issues with the feed fingers during the tests, but this was unrelated to the material, and was not counted against the material. On the two die pairs that did not have problems with the feed fingers, die life was comparable to the current material, although when the dies failed with 80/20B, it was the reverse die that failed, as opposed to the current material seeing die failure on the obverse.

Table 5-3. Treated 80/20B Die Life (Five-Cent)

Die Pair	Die Life (strikes)	Failure Mode
1st	454,000	No objectionable defects noted
2nd	1,095*	Die clash on fingers; retired and installed die pair #3
3rd	470,000	No objectionable defects noted
4th	---*	Die clash on fingers before start; replaced with die pair #5
5th	47,931*	Problems continued with fingers; ended pre-production run and emptied the feed hopper
Overall	924,000	Average 462,000

* - Die retired prematurely; not counted toward overall or average.

5.2.2. Multi-Ply-Plated Steel (Five-Cent)

The Mint used the Canadian-standard upset profile provided by RCM. Due to the abrasive nature of the nickel surface, protective die coatings were required. This is not a practice the Mint uses except for numismatic coins, so the dies were sent to the RCM for coating with their Physical Vapor Deposition (PVD) process and recipe. As their practice was to polish the die surface before coating, some dies were coated without polishing and others with to provide results that would guide future practices. For the pre-production runs, the Mint only used the polished dies which were buffed after PVD coating.

Blank surfaces were prepared per the standard practice the RCM uses on its coinage and the material they provide to other world mints. Progression strikes of standard-crown test dies showed non-fill in high-relief areas (i.e., Martha's bonnet) at up to 60 tonnes, well above the normal circulating strike tonnage of 54 tonnes. The decision was made to use 54 tonnes as the aim tonnage for standard-crown dies. Aim tonnage for the half-crown dies was set at 52 tonnes.

Table 5-4. MPPS Die Life (Five-Cent)

Die Pair	Crown	Die Life (strikes)	Failure Mode
1st	Standard Not Polished	125,779	Crack noticed on bonnet on obverse at 100,000. Crack started at 20,000 strikes. Die retired due to obverse crack.
2nd	Standard Not Polished	67,121	Crack on obverse
3rd	Half Polished	267,000 (500,146)	At 194,000 strikes, noticed defect on the nose (Obverse). At 267,000 strikes the defect was significant enough that the die should have been retired. Continued running to see what additional defects would manifest. At 442,000 piece-outs seen on reverse near the letter F. Ended run after 500,000 strikes.
4th	Half Polished	138,568	Retired die due to crack in nose area of the obverse
5th	Half Polished	103,310	At 40,000 strikes noticed the die coating starting to fail, continued run until crack or piece out. Pulled die at 103,310 for excessive tool marks and coating failure on the obverse.
6th	Half Polished	108,517	Crack on nose seen at 89,000. Stopped run at 108,517 due to crack on obverse.
Overall		810,295 (1,043,441)	Average of 135,049 strikes

Pre-production strikes of standard crown dies were conducted at tonnage comparable to that used for the current material, although given that the features were not optimized for this material and lack of fill was observed in high-relief areas on the obverse design. Pre-production strikes using half-crown dies were conducted at lower tonnage than current strike tonnage.

Coin edge thickness was within specifications, but measurably greater than current coins struck at higher tonnage. Multi-Ply Plated Steel five-cent exhibited premature die retirements as compared to the baseline. Defects seen included cracks, tool marks, and die coating failures. The coating failures are felt to be related to metal oxides on the dies surfaces. PVD coatings typically do not adhere as well to metal oxides as elemental metal. The cracks were present on both the Standard Crown and Half-Crown Martha Washington designs, which illustrates that the feature changes necessary to accommodate plated-steel material would not just be a lowering of the relief/crown.

More feature changes would be required. Improvement in coinability and die life could be possible with an optimization of the Martha Washington designs to be more compatible with the MPPS. This would include a softening of detail, adjustments in the height and degree of image detail, as well as adjustments to the lettering. These changes would not affect the public recognition, but would diminish the aesthetics of the circulating coin appearance.

There is a significant gap though between the averages of 135K and the desired baseline performance of 500K so it is unlikely that the design and/or upset profile changes alone will close the die-life gap fully; therefore, some reduction in die life is to be expected with this alternative material. This is confirmed by RCM's experience of 350K die life on their five-cent coin. Given the feature changes and lower anticipated die life, this material should be considered as feasible, but Less than Current in coinability and die wear.

5.2.3. Multi-Ply Plated Steel Quarter-Dollar

The upset profile provided was RCM 3M with angle A[40] moved closer to the blank edge to address the concentric ring observed on test pieces stamped from previous variability lot planchets. As with the five-cent, the nonsense dies were sent to the RCM for coating to protect against the increased wear encountered from the nickel. Blank surface preparation was per the standard practice the RCM uses on its coinage and the material they provide to other world mints. Progression strikes set aim tonnage at 64 tonnes for the standard crown and 62 tonnes for the half-crown.

[40] Angle of the top edge of the upset with respect to the flat surface on a drawing that shows the exact upset profile from a side-view.

Table 5-5. MPPS Die Life (Quarter-Dollar)

Die Pair	Crown	Die Life (strikes)	Failure Mode
1st	Standard Not Polished	152,179	Noticed crack on bonnet at 20,000 under microscope, continue to run, retired from service due to coating failure.
2nd	Standard Not Polished	242,682	At 180,000 noticed small mark on obverse chin and start of crack on bonnet. Retired dies due to crack on bonnet.
3rd	Half Polished	106,036	Noticed a "glow" appearance on both sides of the pieces soon after start-up. Noticed crack on reverse in the rhino's body at 76K. At 80K, rev crack getting larger and crack starting in obverse bonnet area. Retired dies due to cracks on both sides.
4th	Half Polished	155,957	Still see a "glow" on both sides of the pieces after start-up. Defect starting on the obverse chin area at 27K. Crack developing on reverse in the rhino body. Retired dies due to cracks on both sides.
5th	Half Polished	318,986	Crack starting on obverse in the bonnet area at 215K, cracks noticed on the reverse in the mountain field at 250K. Retired dies due to crack on obverse bonnet area.
6th	Standard not polished	231,344	Crack starting in obverse bonnet area at 102K. Retired dies due to obverse crack and delaminated coating.
7th	Standard not polished	150,030	Noticed coating peeling at 125K lower bust area, retired dies due to coating failure.
8th	Half not polished	140,304	Retired due to coating failure in the obverse field area.
Overall		776,235 (721,283)	Standard Crown 194,059 (Half-Crown 180,321)

Tonnage was comparable to that used for the current material, although given the features were not optimized for this material, a balancing was needed between desired coin fill and dimensions. Multi-Ply Plated Steel exhibited premature die retirements as compared to the baseline. Defects seen included cracks, tool marks, and die coating failures. The coating failures are felt to be related to metal oxides on the dies surfaces. PVD coatings typically do not adhere as well to metal oxides as elemental metal. The cracks were present on both the

Standard Crown and Half-Crown Martha Washington designs, which illustrates that the design changes necessary would not just be a lowering of the relief/crown. Improvement in coinability and die life could be possible with an optimization of the Martha Washington designs to be more compatible with the MPPS.

The current circulating coin design will need to be modified if this material is to be used. This would involve a lowering and softening of details in the image and lettering. This would not affect the public recognition, but would diminish the aesthetics of the circulating coin.

There is a significant gap between the averages of 188K and the baseline performance of 500K, so it is unlikely that the design and/or upset profile changes alone will close the die life gap and some reduction in die life is to be expected with this alternative material. This is confirmed by RCM's experience of 350K on their 25-cent coin. Given the need for feature changes and lower anticipated die life, this material should be considered as feasible, but Less than Current in coinability and die wear.

5.2.4. Nickel-Plated Steel Five-Cent

The pre-production upset profile provided was modified based on feedback provided to The Royal Mint after striking variability lots. Earlier variability lots exhibited premature edge fill, which was not observed during pre-production strikes. As with the MPPS, the five-cent nonsense dies were sent to The Royal Mint for coating to protect against the increased wear encountered from the nickel surface. Blank surface preparation was per the standard practice the RM uses on its coinage and the material they provide to other world mints. Progression strikes set aim tonnage at 54 tonnes for the standard crown.

Table 5-6. NPS Die Life (Five-Cent)

Die Pair	Die Prep	Die Life (strikes)	Failure Mode
1st	Standard; Not polished	75,542	Wear seen within the first 20,000 strikes, especially on the reverse at the 10 and 2 position. Checked die height and was ok, polished the die and resumed striking. Wear marks continued and losing detail on the reverse. Secured run due to crack on reverse left side of building to coin edge.
2nd	Standard; Polished	252,515	28,000 strikes finger smashed and others severely worn requiring change. Continued feed finger and blank feeding issues. Retired die pair due to die clash.
3rd	Standard; Polished	270,218	Feed finger and blank feed issues encountered from the start. Coins show wear, especially around the lettering. Crack staring at 100,000 strikes on Obv top of bonnet, scattered small die coating failures. Started practice of changing fingers every 80,000 strikes. Retired die pair due to crack on obverse in the bonnet and PVD coating failures.
4th	Standard; Not polished	80,001	Oilers were turned on as a trial, obverse becoming shiny; reverse still shows a matte finish. Widespread wear noted at 67,000 strikes on obverse and increasing wear on reverse. Numerous coating failures and crack starting in nose. Retired die due to excessive wear.
5th	Standard; Not polished	76,953	Conducted strikes with oilers off. Obverse die worn in a manner similar to the 1st "not polished" die pair and did not become shiny as the 4th die pair with oilers on. Dies retired due to excessive wear.
Overall		755,229	Overall average of 151,046 strikes Not Polished 77, 499 strikes Polished 261,367 strikes

Tonnage was comparable to that used for the current material with both fill and dimensions acceptable. Nickel-plated steel exhibited premature die retirements though as compared to the baseline. Defects seen included cracks, excessive wear, tool marks and die coating failures. The coating failures are felt to be related to metal oxides on the dies surfaces. PVD coatings typically do not adhere as well to metal oxides as elemental metal.

The cracks were present on both the Obverse (bonnet area) and Reverse (building top corner to coin edge). A significant difference was seen between the Not Polished and Polished die life indicating that going forward circulating dies would need to be polished to provide a more uniform surface and one that was free of oxides.

The planchets and struck pieces exhibited indications of poor lubrication (severe bridging in the feed hopper and Kuster Cart) and that needs to be investigated further with the RM. The excessive wear on the press parts, is unacceptable and must be resolved to support sustained coining operations. Improvement in coinability and die life could be possible with an optimization of the Martha Washington designs to be more compatible with the NPS.

The hardness check on the retained planchets showed the NPS material to be about 20 percent harder than the current material and harder than the RCM plated steel. Also the upset profile appeared sharper vs. the current material's flatter configuration. Both of which, along with the poor lubrication, could also have contributed to the excessive wear. Most definitely there would need to be some accommodation with the current circulating coin design images and features if this material was to be used. The design changes would not affect the public recognition, but would diminish the circulating coin's aesthetics. The blank lubrication and part wear also needs to be addressed to make the material viable.

Since the material is utilized in the United Kingdom and many other countries this is possible, but will require optimization trials. There is a significant gap though between the averages of 261K on the polished coated dies and the baseline performance of 500K so while it is possible to double the die life with changes in features and lubrication; it is not likely that these changes alone will close the die life gap and some reduction in die life is to be expected with this alternative material. The experience of the RM is around 600K strikes for the 5-pence and 10-pence. Experience with other countries they have supplied reflected an average of 447K strikes with a range from 215K to 800K. This average is on coins with very differing designs and the quality standards for those Mints are not known.

Given the need for feature changes and lower anticipated die life, this material should be considered as feasible, but Less than Current in coinability and die wear.

5.2.5. Nickel-Plated Steel Quarter-Dollar

The pre-production upset profile provided was modified based on feedback provided to The Royal Mint after striking variability lots. Strike tonnage was higher than the current material and die life on both standard and half crown was noticeably less. Use of coated and

polished dies was necessary. While improvement could be expected with further optimization of coinage system; obtaining a die life comparable to the current material is not likely. Coinability should be considered Less than Current.

Table 5-7. NPS Die Life (Quarter-Dollar)

Die Pair	Die Prep	Die Life (strikes)	Failure Mode
1st	Standard Polished	145,919	Crack on obv, bottom of bust, was noticed early at 20,000 strikes and later progressed to objectionable (larger, more visible). Cracks on obv (bottom and top of bust) and rev (lettering). Pulled for crack at bottom of bust.
2nd	Standard Polished	105,236	Coating delamination noticed early on, not objectionable. Crack on obverse at 7 o'clock position, radiating out to edge.
3rd	Standard Polished	54,264	Die clash with feed fingers damaged dies so curtailed run. (Not counted toward total, as material was not cause of failure.)
4th	Standard Polished	57,907	Feed finger clash at 961 strikes, dies were inspected and OK – switched to plastic fingers. Retired die later due to crack on obverse radiating out to border.
5th	Half Crown Polished	86,240	Coating delamination noticed after 4,000 strikes, not objectionable. Crack noticed at top of bonnet and bottom of bust at 52K. Retired die due to crack on bottom of the bust getting more pronounced.
6th	Half Crown Polished	101,000	Observed crack starting on bottom of bust around 22,000 strikes. Retired die due to cracks at bottom of bust, also noticed crack on Rhino body on the reverse.
7th	Half Crown Polished	102,600 (127,991)	At 60,000 strikes noticed crack on the bottom of the bust (Obv) and Rhino body (rev), continued to run. A second crack observed developing on the Rhino body at 102,600 strikes, would have been cause for retirement, but elected to run further. At 113,200 strikes noted crack on obv through the letters PROJECT that ran to the border. At 122,300 strikes noted crack in more lettering on the obverse and decided to run out the rest of the feed hopper.
Overall		309,062 (289,840)	Standard Crown average: 103,021 (Half Crown average: 96,613)

Progression strikes were performed on the pilot pre-production material received earlier; performed abbreviated progression strikes to confirm correct tonnage, fill and dimensions, aiming for 66T, but settling on 68T after observing unacceptable diameter at 66T. This was

related to the thicker upset profile which caused the border to completely fill before achieving nominal coin diameter (locked border).

No excessive wear on the coated dies was noted throughout the run and there was less wear on the feed fingers and press parts than experienced on the five-cent. The Mint encountered feed issues throughout the run which required adjustments to the press to accommodate (had to dress up the swivel plate and feed bowl on multiple occasions).

The Mint consistently observed cracks at the bottom of the bust on both the standard and half-crown designs. Also encountered cracks in lettering on both sides and the body of the rhino on the reverse. The cracks in the lettering were not observed during the baseline strikes or on other 25-cent material struck. Ran four die pairs with standard design (one pair clashed so wasn't counted) average of the other three was 101,021 strikes. On the half crown, 3 die pairs were run with an average of 96,613 strikes.

5.3. Conclusions

Table 5-9. Pre-Production Average Die Life

Material	Denomination	Aim Tonnage	Number Die Pairs	Average Die Life
Current Standard Crown	Five-cent	54 tonnes	4	501,706
Current Half Crown	Five-cent	54 tonnes	4	501,627
Current Flat Crown	Five-cent	54 tonnes	4	481,516
80/20B No Lubrication	Five-cent	54 tonnes	5	120,678
80/20B With Lubrication	Five-cent	54 tonnes	2	462,000
Multi-Ply Plated Steel – Standard Crown	Five-cent	54 tonnes	2	96,450
Multi-Ply Plated Steel – Half Crown	Five-cent	52 tonnes	4	154,349
Nickel Plated Steel	Five-cent	54 tonnes	5	Overall 151,046 Not Polished 77,499 Polished 261,367
Current Standard Crown	Quarter-dollar	62 tonnes	4	489,777
Current Half Crown	Quarter-dollar	62 tonnes	3	500,618
Multi-Ply Plated Steel Standard Crown	Quarter-dollar	64 tonnes	4	194,059
Multi-Ply Plated Steel Half Crown	Quarter-dollar	64 tonnes	4	180,321
Nickel Plated Steel Standard Crown	Quarter-dollar	68 tonnes	3	103,021
Nickel Plated Steel Half Crown	Quarter-dollar	68 tonnes	3	96,613

Results from the pre-production testing support the following findings:

- 80/20 tonnage (54T) was comparable to that used for the current material, with fill and dimensions good. Die life was also comparable as was the mode of failure (cracks). One difference was that the reverse exhibited cracks, while on the current material the obverse is the normal side to fail. The slight difference in composition did not affect the coinability once proper blank treatment was applied.
- Nickel-plated material will require polished and coated dies for circulating coin production.

- Wear resistance of press components in contact with nickel-plated materials must be increased.
- Plated-steel material will require changes in the design, specifically a softening of image and lettering and lowering of detail height. These changes should not affect the public recognition of coins, but could diminish the aesthetics of the circulating coin.

6. Findings/Conclusions and Recommendations

Two separate types of alternatives were considered during Phase II testing/evaluation. The first was a material with an EMS and piece weight that was potentially seamless with the current material. The second were co-circulate alternatives where the EMS differed from the current material and the piece weight would vary from the current material by 4 percent or more.

Potentially seamless alternatives would not require changes to the coin acceptors, but would only offer modest material savings (approximately 3 percent). Co-circulate alternatives provide much greater materials savings (20-35 percent), but would require significant stakeholder conversion costs to accommodate the different EMS.

- Potentially seamless alternative evaluated: 80/20
- Co-circulate alternatives evaluated: Nickel-plated steel (NPS)
  Multi-ply-plated steel (MPPS)
  Stainless steel
  Copper-plated zinc (CPZ)
  Tin-plated CPZ (TPCPZ)

6.1. Findings and Conclusions

Seamless Material

1. A variant of today's current cupronickel composition, termed 80/20, which has a lower nickel content with higher manganese, was found to be seamless when tested by three separate coin acceptor manufacturers.[41] The Mint estimated this material would provide approximately $5.25M annual savings ($3.2M for the five-cent, $0.8M for the dime, $1.25 for the quarter-dollar) with no impact on the public or on stakeholders.

2. 80/20 matches the current material in both EMS and in piece weight, having a weight that falls within legally accepted variances for the current material.

[41] In testing, 80/20 was 100% accepted by all three coin acceptor manufacturers.

3. Initial testing of other, potentially seamless, leaner-copper alternatives shows potential for further incremental material savings without presenting any color changes or corrosion-resistance changes.

Co-Circulate Materials

4. Plated-steel materials are a viable option for the five-cent (further testing will determine feasibility for the dime), and offer up to approximately $29M in savings annually over current materials. However, plated-steel materials have increased risks of fraud and counterfeit, and are used in low-value foreign coins, all of which make the materials not feasible for use in the quarter-dollar. They also have a significantly lower die life, which, if not mitigated (see #6, below), could increase production and labor costs, and reduce the savings the materials might offer.

5. Stainless steel, while resistant to corrosion, has a hardness that can negatively impact its coinability. Control of cold-rolling reduction and proper annealing of the right grades demonstrated the ability to mitigate this factor, and improves the coinability of stainless steel, warranting further testing and evaluation. (See attached Stainless Feasibility Study and its Executive Summary in Section 8.)

Production Improvement

6. Adjusting the height of relief/crown on our current coin designs by a fixed percentage introduced other issues, such as outer elements (e.g., the border) filling before inner ones, or the flow of the material changing. It became clear that changes to the coin features—including adjustments to the height of relief/crown, planchet profile, smoothing of design, softening of the letters, and less-detailed images in general—must be treated as a collective system. This system involves not only the items mentioned here, but also matching planchet-die geometry, strike force, die lubrication/coating/polishing, and other variables.

7. Striking of coins with an outer nickel layer (whether single-layer NPS or multilayer MPPS) will require that circulating dies be polished (to provide a uniform and smooth surface) and coated (to provide sufficient abrasion resistance). PVD coatings on U.S.-Mint-manufactured dies demonstrated poor adherence to die surfaces (coating delamination).

8. To accommodate the abrasive outer nickel plating on NPS and MPPS, coating and/or replacement of parts that contact the planchet/coin will be required in production

equipment (conveyors, material handling, press feed/takeaway parts and coin counters). This will reduce identified material savings by an estimated $6M[42] per year. A similar accommodation will be required by all external coin processors and handlers to address the increased wear associated with nickel surfaces.

9. Variability and Pre-production trials indicate planchet lubrication is a critical, but not-yet-optimized variable impacting coining performance with alternative materials. The application of Carboshield BTX to our current cupronickel-based material significantly improved die life and effectively raised the bar for alternatives. However, it took the Mint over three years to develop and implement this lubricant/anti-tarnish material. The Mint will need to develop a similar development process for alternative materials.

10. The inclusion of more than just nickel and copper in leaner-copper-based alloys impacts hardness and more critically conductivity. This will require development of the annealing practices and also slight changes to the coin designs' relief/crown.

11. Test strikes with different material, die designs, and planchet upset profiles confirm that collectively these factors need to be treated as a complete system when making changes. Results seen from changing one variable cannot be interpreted as solely related to that one factor. This means changes to die designs, planchet upset, and material composition will require structured trials to gain a broader understanding and effectively interpret results.

Terminated Materials

12. Testing of plated zinc alternatives (copper-plated zinc (CPZ) and tin-plated copper-plated zinc (TPCPZ)) showed insufficient wear and durability properties for consideration on heavier denominations than the current one-cent CPZ application. Additionally, TPCPZ exhibited galvanic corrosion when copper and tin, two dissimilar metals were exposed to the environment during wear, rendering this construction unsuitable for U.S. coins.

[42] According to Schuler, the manufacturer of the presses in the Mint.

6.2. Recommendations for Further Study

1. Continue 80/20 Testing and Evaluation
    a. Continue larger-scale testing of 80/20 and develop a final specification that can be utilized by current and other strip suppliers.
    b. Conduct feasibility, variability and pre-production testing on cladding 80/20 to a copper core as an alternative for the clad denominations of dime, quarter-dollar and half-dollar. Direct cost savings from this change would be limited, but continuing to clad these coins with the same alloy used in the five-cent would streamline material production.
2. Pursue seamless alloy development

    Continue alloy development of other, potentially seamless, leaner-copper alternatives to provide opportunity for additional incremental materials savings without impacting coin acceptors and coin processors. Initial testing indicates further opportunity for incremental material cost reductions with a composition evolving over several progressive steps.
3. Continue stainless steel R&D
    a. Continue larger-scale variability and pre-production testing on the two stainless steel grades identified in the attached Stainless Feasibility Study.
    b. Conduct testing and evaluation of monolithic stainless steel as a clad outer layer as a co-circulate material. Engineering calculations indicate this combination could exhibit a similar EMS to the current clad coins and enable the copper core thickness to be reduced, providing incremental material savings and a reduction in the use of the more-expensive and price-volatile nickel. Its piece weight, however, would be lighter.
4. Explore production improvements
    a. Investigate push-back blanking and determine if that is a technically feasible and cost-effective production method that would enable elimination of internal annealing on strip material (see attached Laser-Blanking Study).
    b. Pursue more-structured test strikes on different coin materials, modified design aspects, and upset profile configurations to increase the Mint's understanding of the overall coin manufacturing system. These results can be utilized to improve production efficiencies on current coin materials and provide for quicker evaluation of future materials. Results from structured trials can be used to support predictive model development and reduce the need for time-consuming iterative test strikes.

7. Bi-Metallic Coin Study

Concurrent Technologies Corporation (CTC) performed the study on bi-metallic coins, and recommended against the proposal to make bi-metallic five cents from current one-cent coins as the center and five-cent coins as the outer ring. CTC also determined that bi-metallic construction would be advisable for coin denominations above the dollar. Below is the Executive Summary.

7.1. Executive Summary

The Mint sought to leverage CTC's recent experience in the *Alternative Metals Study* to identify and quantify many of the issues associated with material selection, supply, production, manufacturing and public use of bi-metallic coins.

CTC provided a tabular database entitled "World Bi-Metallic Coins" that includes countries where the bi-metallic coins are issued, along with their denomination, images of the obverse and reverse (when available), materials of construction, total coin weight and coin dimensional specifications (thickness and diameter of the outer ring and core), inside-diameter-to-outside-diameter (ID/OD) ratio, approximate United States (U.S.) equivalent monetary value, Web site for images and other details, and the country's mint or government Web site. A total of 194 countries (including the United States) populate the World Bi-Metallic Coins database. Of the 194 total countries surveyed, 92 countries have one or more bi-metallic coins in their nation's coin set. From the World Bi-Metallic Coins database, CTC observed that the ID/OD ratio of bi-metallic coins throughout the world varied between a minimum of 0.56 and a maximum of 0.78. A mean ID/OD ratio of 0.68 was found.

CTC also investigated the feasibility and estimated unit cost of creating a circulating bi-metallic coin using the current one-cent coin/planchet as an insert to an outer ring made from a current five-cent coin/planchet. Demonstration pieces were fabricated (i.e., not struck) and provided to the United States Mint to illustrate the placement of an already circulated one-cent coin/planchet inside an outer ring made from an already circulated five-cent coin/planchet. These demonstration pieces also illustrated the effects of using an ID/OD ratio of 0.90 (full diameter of a one-cent coin) and 0.68 (world mean ID/OD ratio); the outer rim of material was removed from the one-cent coin to achieve an ID/OD ratio of 0.68. Estimated unit costs were calculated for each possible one-cent coin/planchet in a five-cent coin/planchet scenario.

CTC investigated the feasibility and cost effectiveness of utilizing a bi-metallic coin for circulating coin denominations other than the five-cent coin. Manufacturing equipment needed to produce bi-metallic coinage and production changes necessary to support producing a bi-metallic coin for the United States in circulating coin quantities was documented. Factors considered in the selection of potential metal alloys included color, electrical conductivity, tarnish and corrosion resistance, wear resistance, electrochemical compatibility with other alloys, cost, mechanical properties, coefficient of thermal expansion, recyclability and environmental impact. By their nature, bi-metallic coins require metals of differing colors. Of the many alternative alloys considered, the majority of those selected for further evaluation was either already being used or were similar to alloys already being used in production of world circulating bi-metallic coins. This included copper-nickel alloys, various brasses and stainless steels.

Hypothetical two- and five-dollar circulating coins were contemplated and several constructions were evaluated. This investigation was motivated by the discovery that at least six bi-metallic world circulating coins, whose value exceeds $2 U.S. dollars, are currently in circulation throughout the world. The hypothetical two- and five-dollar United States coins were assumed to be 28 millimeters (mm) and 29.2 mm in diameter and 2.45 mm and 2.75 mm in rim height, respectively. These diameters fall between those of the legacy one-dollar and half-dollar coins. The thickness of these two hypothetical coins is greater than any current U.S. coin, but is less than other coins, including the United Kingdom one-pound coin, circulated throughout the world. These hypothetical bi-metallic coins could be produced by the United States Mint for 0.22 to 0.27 $/coin, depending upon the materials used in their construction. Additional development, beyond the engineering cost analysis described here, must be completed prior to selecting any of these designs for production.

Changes to the size and construction of the half-dollar coin were contemplated. A bi-metallic construction was evaluated having an inside diameter of 14.8 mm, an outside diameter of 22.73 mm and a rim height of 2.31 mm. The core of this hypothetical half-dollar coin was made of homogeneous 75Cu-25Ni cupronickel while the outer ring was made of Nordic gold. The projected unit cost for this coin was 0.143 $/coin (using FY2014 metal cost and FY2013 United States Mint indirect costs for the quarter-dollar coin). The unit cost to produce legacy 75Cu-25Ni-clad copper half-dollar coins for circulation in FY2006—the last year that circulating half-dollar coins were produced—was 0.1749 $/coin; the projected cost to produce legacy 75Cu-25Ni-clad copper half-dollar coins for circulation in FY2014 was

0.19132 $/coin. Therefore, the hypothetical bi-metallic half-dollar circulating coin would offer a 25 percent reduction in unit cost compared to the legacy construction.

CTC performed a regulatory analysis of the applicable environmental issues, including those related to air pollutant emissions, solid and/or hazardous waste management, water use and wastewater discharges. CTC did not undertake a formal National Environmental Policy Act (NEPA) environmental assessment as that was beyond the scope of the current project. Recyclability of individual metal components prior to assembly was considered for the materials considered as potential bi-metallic coin candidates. Two methods of recycling bi-metallic coins were considered: 1) separation of the two metal constituents into two unique streams and 2) blending of both metal constituents into a single recycle stream.

Based upon the information gathered from each of the above factors, CTC offers the following recommendations for consideration and implementation by the United States Mint. Detailed descriptions of the study's findings and conclusions can be found in the body of the report.

- **A bi-metallic five-cent coin, utilizing any materials for coin construction, will need to co-circulate with the existing homogeneous cupronickel five-cent coin.** If all materials in a newly introduced bi-metallic five-cent circulating coin are non-ferromagnetic, then a one-time investment of $277M is required by the United States coin stakeholder community to accept the new coin construction. However, if any of the components are ferromagnetic, then a one-time investment of $532M to upgrade or replace existing coin-acceptance equipment will be needed. If a bi-metallic five-cent coin of different weight than the legacy five-cent coin was introduced into circulation, additional sorting and handling would be required by United States coin and currency handlers; the cost associated with this additional handling was estimated to be $3.75M per year.
- **Do not pursue concept of one-cent core in five-cent outer ring using either previously circulated coins or unstruck planchets.** Significant technical and cost issues have been identified with this bi-metallic coin construction.
    - Technical issues, which cannot be overcome and therefore preclude the use of either previously circulated coins or unstruck planchets, include the following.
        - A full-diameter one-cent coin/planchet placed inside a five-cent coin/planchet outer ring would yield an inside-to-outside diameter ratio of 0.90, which is well beyond the ratio of all other known bi-metallic coins in circulation throughout the world. An outer ring of such narrow width will be subject to warping, denting, crushing and

other damage during normal handling operations. In addition, maintaining stability during assembly and striking will be problematic and options for locking mechanisms between the one-cent coin/planchet core and five-cent coin/planchet outer ring will be severely limited with such a narrow outer ring.

- Use of a reduced-diameter, previously circulated one-cent coin/planchet will expose the zinc core, which would quickly corrode during normal handling and exposure to the environment. This will lead to decreased coin life and public confusion.
- A full-diameter five-cent coin will not fit into the striking press collar unless the outside diameter of the five-cent coin is first reduced by upsetting or machining. This adds another processing step to the production of such bi-metallic coins.
- The approximately 0.3-mm thickness mismatch between the one-cent and five-cent coins/planchets violates a recommendation by the leading supplier of bi-metallic coin presses to keep such thickness mismatches to less than 0.1 mm. Thickness mismatches greater than 0.1 mm would tend to wear unevenly, collect debris along the corner formed by the thinner component at the junction of the two components, likely induce stress concentrations in the striking dies thereby shortening useful die life and potentially require larger acceptance windows in automated coin-acceptance devices due to inconsistencies associated with placement of the two components in the thickness direction.
- The one-cent's date of striking, Lincoln's profile, the shield and "ONE CENT" are clearly visible on those demonstration pieces based on the use of a previously circulated one-cent coin. During striking of the resulting bi-metallic five-cent coin, a "double strike" condition would occur as the original images would appear behind the newly struck image. Furthermore, the alignment of the two images would be random leading to wide variations in the final struck image and potentially leading to increased variability in finished coin quality.

- Introduction of such a bi-metallic five-cent coin into circulation, would not offer the same amount of unit cost savings as other alternative five-cent coin constructions as identified in the *Alternative Metals Study*. Furthermore, additional sorting and handling of this construction, which would require co-circulation, would require an estimated increase of $3.75M/year by the coin and currency handlers. Also, less expensive options consisting of homogeneous non-ferromagnetic stainless steel construction were identified in the *Alternative Metals Study*.

- An option to use a full-thickness copper-plated zinc core was considered. Of the three constructions evaluated, only one provided any significant unit cost savings. However, this construction relied on nickel-plated steel for the outer ring resulting in a complex metal mixture that:
    - Is susceptible to rapid corrosion
    - Requires upgrades or replacements for many coin-acceptance devices by domestic coin stakeholders at a cost of $532M since the associated steel alloys are ferromagnetic
    - Requires additional sorting and handling by the coin and currency handlers at an annual cost of $3.75M.

- **Consider use of a clad core for any bi-metallic coins with a face value greater than or equal to one dollar to increase security and visual uniqueness.** According to the guidelines defined in the European Vending Association (EVA) Coin Design Handbook, bi-metallic coins are suitable for higher-value coins, which are defined as those whose value is approximately greater than 50 Euro cents (approximately 68 United States cents). Security features, such as clad core bi-metallic construction, are highly recommended to deter counterfeits—the clad-core bi-metallic construction is the highest security feature commonly available in circulating coins according to the EVA Coin Design Handbook. The added cost for a clad core bi-metallic coin was found to be between 0.02 and 0.03 $/coin more than a homogeneous core design. Therefore, the added security offered by a clad core was judged to be worth the additional cost for coins that typically can be produced in circulation quantities for 0.18 to 0.27 $/coin depending on material selection and coin dimensions.
- **Use an ID/OD ratio between 0.60 and 0.75 for bi-metallic coins.** Maintaining this ID/OD ratio is consistent with the majority of bi-metallic circulating coins in the world. This ratio is consistent with a recommendation by the manufacturer of the overwhelming majority of the world's coin striking presses to keep the exposed areas of the two components (i.e., the core and outer ring) approximately equal. Deviations from equal areas sometimes occur to minimize the quantity of the more expensive of the two components of a bi-metallic coin. The unit cost of bi-metallic coins did not vary widely over an ID/OD ratio between 0.60 and 0.75 indicating that other factors, including artistic appeal, may play an important role in selecting the desired ID/OD ratio for any given bi-metallic coin.
- **Use a minimum outer ring width (i.e., the difference between the outside radius and inside radius) of 4.0 mm.** A leading coin striking press manufacturer recommends that the width of the outer ring be a minimum of 3.5–4.5 mm to ensure that high-quality outer rings are delivered to, and maintained during operations within, the bi-metallic coining presses. A range in widths is given since the recommended value for

any given coin depends on the thickness and outside diameter of the outer ring; larger widths apply to outer rings of larger diameter.

- **Prior to introducing any circulating coin of new construction, including bi-metallic construction, engage the coin-acceptor community to test for uniqueness from other circulating coins used throughout the world.** The United States Mint should provide manufacturers of automated coin-processing equipment samples of the final coins (made from the new materials of construction) at least 18 months in advance of the expected date for introducing these coins into circulation. Doing so will provide the coin-processing industry time to respond to changes in the construction of coins. These samples are expected to be used to design the necessary changes to the manufacturer's equipment and to get their clients prepared for the introduction of these coins into circulation.
- **Within the sizes of the current United States coin set, use of piercings from high-denomination bi-metallic coins is not practical for low-value coins of smaller diameter.** In no cases were the thickness and diameter of such piercings (within the bounds of acceptable ID/OD ratios for bi-metallic coins) acceptable for striking. In all cases, the piercing size violated the thickness and diameter tolerances required of planchets used to produce these low-denomination coins.
- **The capital cost required by the United States Mint to produce bi-metallic coins would increase the unit cost of coins by approximately 0.0066 $/coin.** This assumes the use of piercing presses, new vertical coin striking presses, additional upsetting mills and inspection of outer rings. A 10-year return on investment was used for this calculation.

Production of bi-metallic coins at the United States Mint will require additional process steps and production equipment compared to the legacy coin production. Compared to the production of homogeneous or clad coins, bi-metallic coins require the following additional processing steps: one additional blanking operation, one additional upsetting operation, a piercing operation and inspection of the outer ring. Two options exist for production of bi-metallic coins: 1) processing of materials from rolled coils to finished bi-metallic coins at the United States Mint and 2) striking pre-assembled bi-metallic planchets produced by a supplier. Both options will require purchase of additional vertical presses and support equipment; a similar number of additional vertical presses and support equipment would be required for either option to meet the production demands of the United States Mint. In the first option, the United States Mint would purchase the equipment directly; in the second option, the bi-metallic planchet supplier would purchase the equipment (and indirectly pass the cost onto the United States Mint). In the first option, the United States Mint could retire their current horizontal striking presses (or use them for production of non-bi-metallic

coins). However, if the second of these options is exercised, then the United States Mint must still use its existing horizontal striking presses to strike the bi-metallic pre-assembled planchets. In effect, an additional, and costly processing step will be required for this option: the assembled components must be compressed with a flat die to lock them together and to ensure they remain intact during subsequent handling, shipping and loading into the horizontal striking presses at the United States Mint. As a result, CTC expects the cost impact to the United States Mint for this second production option to be higher than having the United States Mint complete all production steps in-house.

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8. Stainless Steel Feasibility Study

Concurrent Technologies Corporation (CTC) performed the study on Stainless Steel alternatives, and published that report to the Mint in early July 2014. Below is the Executive Summary, formatted for this report.

8.1. Executive Summary

The United States Mint sought to leverage CTC's recent experience in the *Alternative Metals Study* and CTC's broad understanding of metals, manufacturing and coin production to identify and quantify many of the issues associated with material selection, supply, production, manufacturing and public use of stainless steel coins. Key to the success of the current effort was the willingness of the suppliers to provide laboratory heats (each weighing approximately 50 pounds) of down selected stainless steel alloys for evaluation. Stainless steel alloys having low hardness, strength and work hardening behavior, while achieving complete die fill and the ability to upset blanks in a softened, annealed state to minimize striking loads and die fatigue, were down selected for this project. The results of this study include the following.

- A material change from cupronickel to a stainless steel alloy for the existing five-cent coin would require co-circulation (although non-seamless) with the legacy coin; non-seamless alternative candidates having a different, possibly unique, EMS and/or a different weight than the incumbent coinage.
- Stainless steel alloys would provide a lower-cost candidate for the five-cent circulating coin.
- Based upon the United-States-Mint-approved cost analysis methodology used, all stainless steel alloys evaluated offer a unit cost saving to the United States Mint for five-cent circulating coins.
- While the unit cost saving to the United States Mint for ferromagnetic alloys were found to be higher than that for non-ferromagnetic alloys, use of ferromagnetic stainless steel coins would have approximately twice the cost impact to the domestic coin stakeholders (including the vending industry, laundromats and others) than would the use of non-ferromagnetic stainless steel coins.
- Rittenhouse and Modified 18-9 LW appeared to offer good striking performance at striking loads that were comparable to those used to manufacture the legacy cupronickel five-cent circulating coins. However, validation of production parameters using production equipment (as opposed to the laboratory-scale heats and equipment evaluated and discussed in this report) at the suppliers need to be

evaluated; therefore, larger scale tests are recommended before attempting a preproduction run.

Based upon these findings, the following recommendations are offered.

- Complete additional technical assessments of Rittenhouse 52 and Modified 18-9 LW stainless steel alloys. Striking of these alloys during tests completed at the United States Mint Research and Development Center in Philadelphia showed complete die fill with reduced coining loads as compared to the incumbent cupronickel five-cent circulating coin.
- Consider only non-ferromagnetic stainless steel alloys for use in five-cent coins to minimize the impact to the domestic coin stakeholders.
- Confirm unit cost estimates by obtaining updated cost quotes from material vendors for production volumes of stainless steel five-cent coins and completing preproduction runs to validate striking die life.
- Apply numerical methods (such as finite element analysis) to predict blanking shear stresses, die fill, die stress and die life for various materials, die shape and process conditions. Doing so will improve the understanding of how these factors interact in advance of actual pre-production trials. The virtual trials will allow for relatively inexpensive investigations of many process design scenarios, which will enhance the probability of achieving successful and meaningful pre-production trials.

9. Laser-Blanking Study

Fraunhofer USA performed the study on laser blanking, and published that report to the Mint in July 2014. Below is the Executive Summary, formatted for this report.

9.1. Executive Summary

In support of the Coin Modernization, Oversight, and Continuity Act of 2010, the U.S. Mint is seeking ways to reduce the cost of producing circulating coins. One potential idea is to replace the current mechanical die blanking and on-site annealing with laser blanking and off-site bulk annealing. A second scenario is to retain the on-site annealing and exchange die-blanking with laser blanking. The U.S. Mint contracted with Fraunhofer USA to investigate the technical and financial feasibility of these ideas.

Fraunhofer conducted a thorough review of the technical issues and found no significant concerns. The review involved laser cutting nine different materials and making sample coin blanks. The sample blanks were characterized for diameter, burr, knit-line, edge condition, grain structure, and hardness in the area adjacent to the laser cutting. Laser cutting of the monolithic 5-cent material was found to be faster and at better edge quality than with any of the clad materials (dime, quarter, and dollar). Sample lots of 100 pieces of 5-cent, dime, quarter, and dollar blanks were sent to the U.S. Mint for evaluation.

A conceptual design was developed along with 3D CAD images showing how multiple lasers working in parallel could meet the production needs of the U.S. Mint. Also an Environmental Assessment was performed which yielded no significant concerns.

Several economic analyses were performed using a range of assumptions and **none of the analyses showed a strongly favorable economic outcome for laser blanking**. When considering laser blanking machines with production capacity equal to the current die blanking machines, laser blanking looks economically unfavorable. When lower production capacity was considered, the economics of laser blanking are roughly equivalent to die blanking within the margin of error of the analysis, making laser blanking not a very compelling avenue for pursuing cost reduction efforts. Perhaps in

the future, if lasers cut faster or become less expensive, that situation might change; but currently the financial feasibility of laser blanking looks challenging.

In the course of this study, Fraunhofer identified a promising alternative to laser blanking called die blanking with a push-back system, which could eliminate the expense of on-site annealing. This system is very similar to the current die blanking and the capital investment looks to be low. Fraunhofer recommends that a study be conducted of a push-back die blanking system for the U.S. Mint.

If the U.S. Mint decides that a lower production capacity meets its needs, then the economics of laser blanking are estimated to be roughly equal with die blanking and laser blanking might be pursued by the U.S. Mint for some of the benefits it offers. Fraunhofer has developed a logical multiphase development process to continue the effort into laser blanking that will address some of the design and production questions while minimizing development expenses.

Circulating coins are manufactured with three successive metal forming steps. 1) Punch out a flat circular disk, called a blank, from a flattened coil of "hard" sheet metal. 2) Raise a ridge along the outer circumference of the blank (known as upsetting the blank) to create what is known as a planchet. 3) Coin the planchet by stamping the top and bottom surfaces with artwork such as the faces of U.S. Presidents and required inscriptions associated with U.S. coinage. The first step in this sequence, blanking, is the subject of the current cost reduction effort.

Mechanical die blanking is a simple process that works like a paper hole-punch with the punch positioned above the sheet metal and the die below. The die sets are constructed with multiple punches so that each time the die closes, as many as 20 blanks are created. The die press runs at 550 strokes per minute which means that over 5 million blanks can be produced in a single 8 hour shift.

In order to punch out a clean flat blank, the coils of sheet metal must be in a so called work-hardened state rather than a soft, or annealed, state. Unfortunately, the final metal forming step (stamping) requires the metal to be in an annealed state. This means that the U.S. Mint must run large and expensive rotary retort furnaces to anneal all the coin blanks on site.

The proposed laser blanking process, however, is capable of directly cutting annealed sheet material. Thus if laser blanking is technically and financially feasible, it would be possible to

eliminate the rotary retort furnaces at the U.S. Mint facilities. The responsibility of annealing the coiled sheet metal material would then be shifted to the metal suppliers who are believed to be able to anneal the metal in bulk coil form at a lower cost compared to the U.S. Mint's rotary retort furnaces.

The work performed by Fraunhofer was structured into four areas

1) Technical feasibility
2) Conceptual design
3) Environmental assessment
4) Economic feasibility

Technical feasibility was performed by cutting out sample blanks using a 6KW Trumpf laser and quantifying the quality of the resulting blanks. In total, nine different materials were cut. Naturally the five existing coin materials were cut, 5-cent[43], Dime, Quarter, Half-Dollar, and Dollar (note that the penny was not tested because it is not blanked at the U.S. Mint). Also, four possible future alternative materials were cut: 304 stainless steel, 430 stainless steel, brass, and silicon steel.

Once the samples were cut, various pieces of metrological equipment were used to quantify six different areas of concern: 1) diameter, 2) burr, 3) edge condition (chamfer), 4) knit-line, 5) grain structure, and 6) hardness in the heat affected zone (HAZ).

The diameter data raised no concerns since the blank diameter is easily adjusted in the machine and the range of diameters (sample to sample variation) was within acceptable limits, less than ±0.002" (±50μm). Some samples were found to be excessively elliptical, a problem that was mostly resolved with improved sample fixturing and would likely be completely resolved by switching to a rotary actuator from the X-Y actuator used in the test setup.

The edge burrs raised no concerns as they were typically around 0.001" (25μm) or less once the laser process parameters were optimized.

[43] The word "nickel" is ambiguous as it can mean either a five cent coin or a silver metallic material. Both the coin and the metal are discussed in this document leading to possible confusion. To reduce the chance of confusion, the term "five-cent" is used in this document to refer to the coin whereas "nickel" is used in reference to the metal.

The edge condition (chamfers) of some of the laser cut blanks raised some initial concerns but ultimately the chamfers were deemed acceptable. Edge chamfers on some of the clad copper blanks (e.g. quarters) were as large as 0.004" (100μm), which raised the initial concerns. However, two additional studies removed the concerns. Firstly, die blanked samples (the current process) were found to have edge chamfers of a similar size (particularly on the quarter blanks). Secondly, a set of die-cut 5-cent blanks were modified to have 0.002", 0.004", and 0.008" chamfers (50, 100, and 200μm) and then processed into coins at the U.S. Mint. The samples were found to produce acceptable coins even with as much as 0.008" (200μm) chamfer on one edge.

Knit-line is a term chosen to describe a small bump at the edge of the coin blank at the location where the laser starts and stops cutting. This bump can be as large as 0.008" (200μm) and is a concern because it could cause problems in feeding the blanks into the upsetting machine or in actually upsetting the blanks. If the knit-line does cause a problem, Fraunhofer is confident that a laser cutting machine could be designed to hold the blank while it is being cut which would eliminate the knit-line.

Grain structure within the HAZ did not raise any concern. Prior to testing, there were concerns that the heat from the laser would create edge hardening which might make upsetting or stamping difficult with laser cut blanks. However, the only observable change was some signs of grain growth when hard samples were cut which indicates the material is softening rather than hardening.

Hardness measurements did not raise any concern, with one exception. When hard samples were laser cut, the material hardness frequently decreased, which is not a concern. When annealed samples were laser-cut, no change in hardness was measured. One exception was 304 stainless steel which showed a significant increase in hardness in the HAZ which might cause difficulties when trying to upset blanks or stamp planchets made from that material. The hardness at the edge of the laser cut 304 blanks increased to 250 (HV100) which is about twice as hard as the current, annealed cupronickel materials being processed at the Mint. A previous alternative metals study performed for the U.S. Mint showed this material was difficult to strike due to its hardness, so any increase in hardness would only make this situation worse.

Overall, laser cutting of blanks appears to be technically feasible. Some careful engineering design might be needed for the laser blanking machine, but no fundamental problems with laser cutting were identified.

While producing high quality laser cut blanks was shown to be possible, it was known that they would need to be cut very quickly. The current mechanical die blanking system cuts metal at the equivalent of 600 linear meters per minute. Testing with the lasers showed that the cutting speed for current coin materials is between 14 and 35 meters per minute. To have a laser machine match the performance of the die blanking machine would require a machine design with multiple lasers, and immediately raised concerns about the cost of the machine.

In order to make an estimate of the cost of laser blanking, it was necessary to have a conceptual design of a laser blanking machine. The overall concept is to have multiple lasers cutting blanks at the same time to improve the throughput of the machine. A number of lasers (perhaps 4) would be mounted side by side across the width of the strip. These lasers would each be mounted on rotary stages that would move in a circular motion. The stages would be actuated with individual actuators or, as a secondary option, with a mechanism that drives them together as a group. The group of stages would also be mounted on a stage that allowed the laser cutting to start (the pierce) slightly to the side of the coin blank. Additional groups of lasers (perhaps 4 rows of 4 lasers, total 16) would be located downstream of the first group to cut more blanks. This layout is actually similar to the punch and die positions in the current blanking machine, although the lasers would likely need more space than punches and dies.

The footprint of the laser machine would be more than the current die-blanking press, but significantly less than the space made available by the elimination of the rotary retort furnace. If the rotary retort furnace is retained, Fraunhofer believes the laser blanking system could still be made to fit within the current footprint, but the engineering design would be more difficult. A laser blanking machine requires a significant amount of support equipment including the lasers themselves, chillers, air handlers, and nitrogen generators which will consume significant floor area. It is recommended that a mezzanine be constructed above the laser cutting machine to hold the various pieces of support equipment. The laser blanking system (with mezzanine) should easily fit within the available floor space of the U.S. Mint. Lower ceiling heights in Denver might require an alternative placement of support equipment.

The environmental assessment raised no concerns. Eliminating the annealing furnaces at the U.S. Mint would eliminate potential sources of both air and water pollution (though neither are really a serious concern as they are carefully managed by the U.S. Mint). Laser cutting

will use additional electricity and the bulk annealing at the suppliers might shift environmental concerns from the U.S. Mint facility to supplier locations, but there is no significant cause for concern.

The financial feasibility study, however, cast significant doubt about the proposed savings from the laser based blanking system. On the positive side, laser blanking of 5-cent coins might be slightly less expensive than the current die blanking owing to the relatively high speed cutting that is possible on the cupro-nickel material that the 5-cent is made from. On the negative side, the slower laser cutting on the clad copper materials (dime, quarter, half-dollar, and dollar) make laser cutting significantly more expensive than the current die blanking. Slower cutting means that more lasers working in parallel are needed, increasing both the cost of the machine and the electricity to run it and also the cost of consumables (e.g. filters). Furthermore, designing a machine that would potentially require over 30 lasers would be a challenge. Fraunhofer is aware of commercial laser cutting machines with 2 lasers, but no more than that. But it is worth noting that current commercial machines are sold based on their flexibility, whereas the U.S. Mint does not need geometric flexibility which greatly simplifies the design and control of multiple lasers.

The economic analysis that looked most favorable for laser blanking was replacing all ten production lines with laser blanking machines with lower production capacity, either half-speed or annealing speed[44]. For this analysis, the economics of laser and die blanking were roughly equal, at least within the uncertainty of the analysis. This analysis could be used as justification to further pursue laser blanking, however, the switch to laser blanking does not look to be a promising venue for significant cost savings and carries some development risks.

One of the key findings from the economic analyses is that the savings from off-site bulk annealing of the coin material proved to be less than expected. This meant that it was not as easy to use the savings from the annealing costs to help cover the cost of laser blanking.

Given that laser blanking appears to be technically feasible but financially uncompelling, there are a few options that can be considered:

1) Take no further action.

[44] A half speed machine is one that has a production capacity of half the current die blanking machine. An annealing speed machine has a production capacity that is equal to the current annealing furnace production capacity. Both are capable of delivering FY2013 production volumes, despite having lower production capacity.

2) Undertake a prototype development effort to make a single laser blanking machine to address issues such as knit-line, rotary stage cutting, and practical cutting speeds. Experience gained from the prototype development would decrease the risks associated with laser blanking, decrease economic uncertainty, and allow the U.S. Mint to gain valuable experience with this new blanking technology.
3) Undertake a study of non-laser based blanking alternatives such as die-blanking with a push-back station that might be able to directly blank annealed material without distorting the blanks.
4) Undertake a study of waterjet cutting blanks.

It is Fraunhofer's recommendation to proceed with option 3 and possibly option 2 above. Die-blanking with a push-back station is viewed as a strong candidate for cost-reducing the blanking operation at the U.S. Mint and laser blanking might be useful as well, although the current analysis suggests it is likely not a strong candidate. Waterjet cutting is believed to be slow and somewhat messy and not likely to be a good fit for the U.S. Mint's application.

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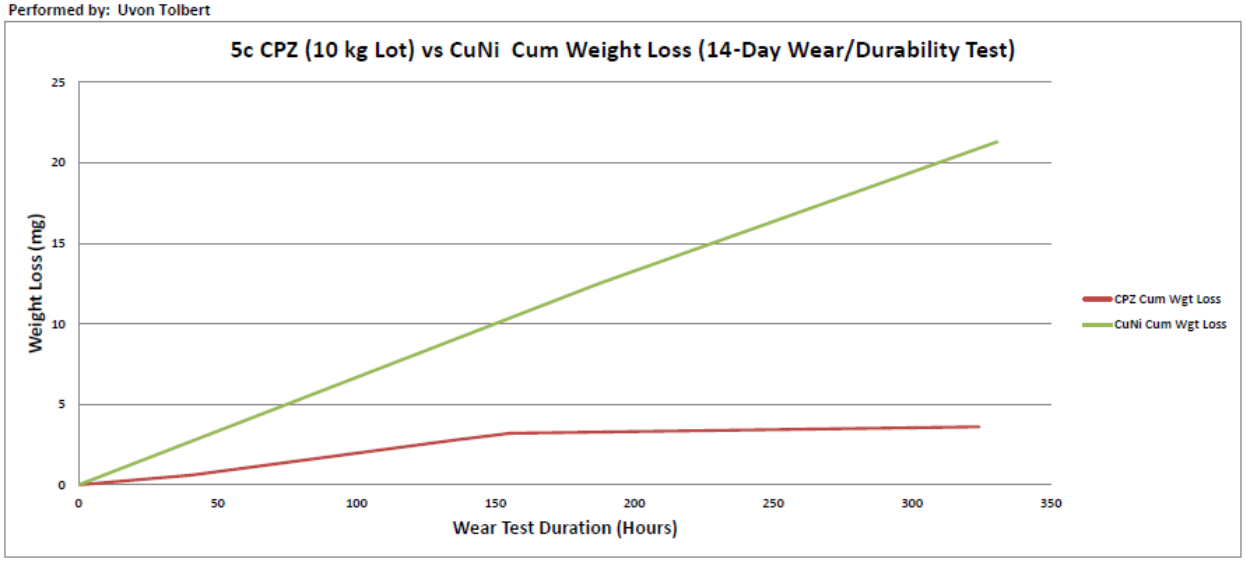
10.Appendices

10.1. Wear Test Results – Variability Lots

10.1.1.Copper-Plated Zinc (CPZ)

WEAR AND DURABILITY TESTING (October 1 - 15, 2013)

Performed by: Uvon Tolbert



Average Weight Loss (per piece): CPZ = 3.6 miligrams
Current 5 cent = 21.3 miligrams

Durability (Edge Deformation): Ending CPZ Edge Thickness = 0.0855"
Ending Current 5-cent Edge Thickness = 0.069"
Deformation = 0.0855 - 0.069 = **0.0165"**

Durability Rating: 5-cent CPZ is rated No Go for durability because edge deformation difference between it and the current 5-cent coin from the same wear chamber exceeded the maximum allowable of 0.010". The soft zinc core is judged to be too soft to reliably withstand impacts and handling (i.e., repeated mechanical coins sorting/counting) expected during circulation. Additionally, the 8-micron copper plating was not thick enough to prevent breakthrough and exposing the zinc core after cycling test pieces 100 times through the coin sorter/validator.

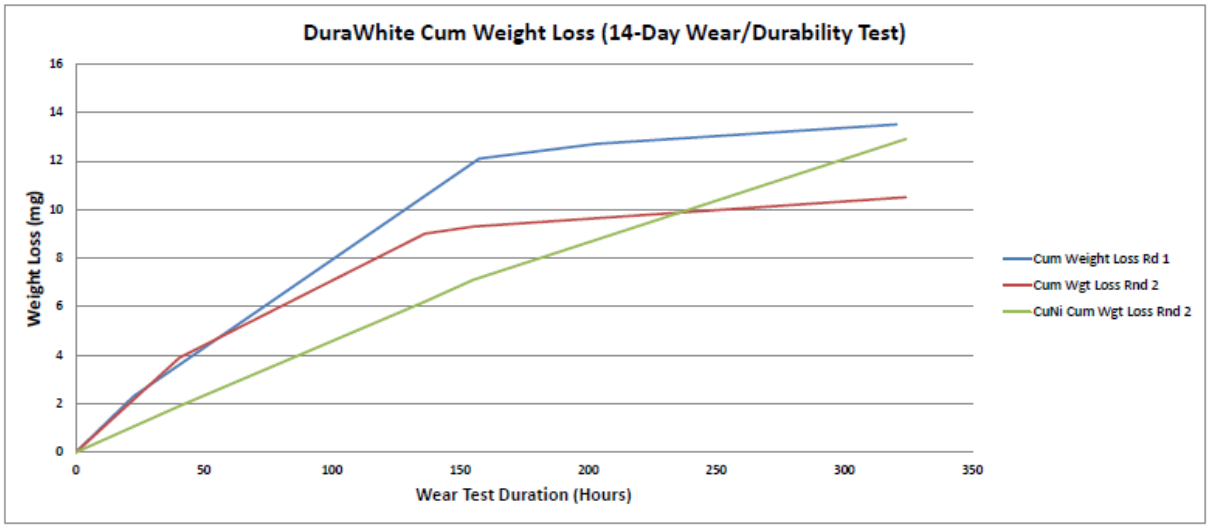
Wear Rating: 5-cent CPZ is rated **Go** for wear resistance based on the first week's weight loss results (see graph above). However, increasing edge thickness as wear testing continued (edge deformation) served to reduce sliding wear to obverse/reverse designs (see graph above) and reducing weight loss.

Overall Rating: No Go

10.1.2.Tin-Plated CPZ (TPCPZ)

TPCPZ Five-Cent (Variability)

WEAR AND DURABILITY TESTING



Average Weight Loss (per piece): DuraWhite Round 1 = 13.5 miligrams
DuraWhite Round 2 = 10.5 miligrams
Cupro-nickel = 12.9 miligrams

Durability (Edge Deformation): Ending DuraWhite Edge Thickness = 0.0867" for Round 1 and 0.089" for Round 2
Ending Cupro-nickel Edge Thickness = 0.070"
Round 1 Deformation = 0.0867 - 0.070 = **0.0167"** Round 2 Deformation = 0.089 - 0.070 = **0.0190"**

Durability Rating: 5-cent DuraWhite is rated No Go for durability because edge deformation difference between it and cupro-nickel 5-cent coin from the same wear chamber exceeded the maximum allowable of 0.010". The soft zinc core is judged to be too soft to reliably withstand impacts and handling (i.e., repeated mechanical coins sorting/counting) expected during circulation. Additionally, the tin/copper plating did not prevent breakthrough and exposure of the zinc core during 14-day wear testing.

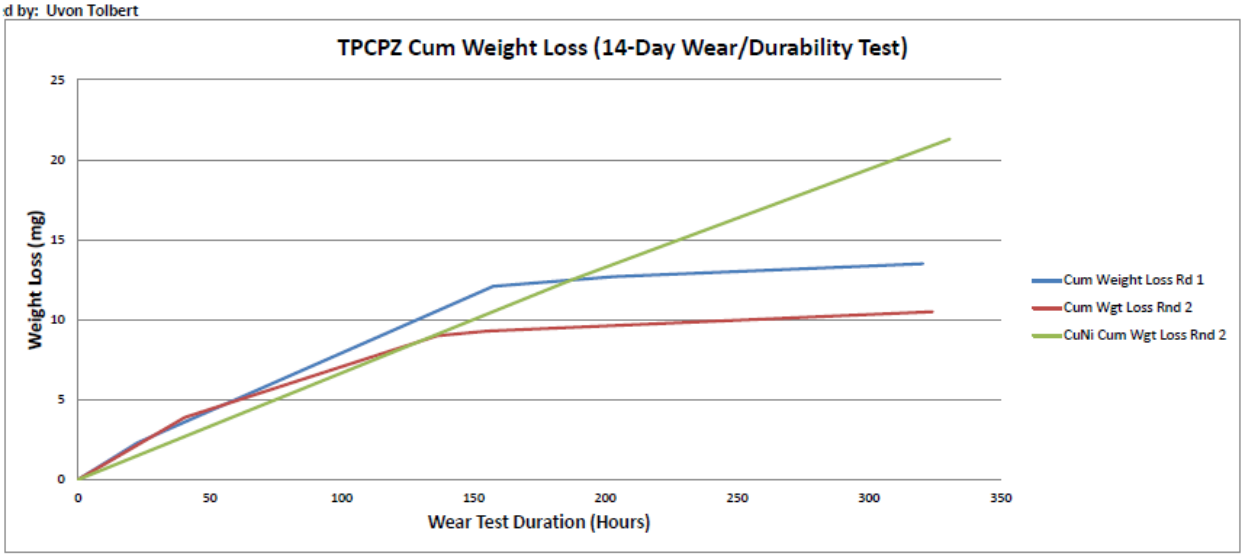
Wear Rating: 5-cent DuraWhite is rated No Go for wear resistance based on the first 2-day weight loss results. These wear rates were higher than the maximum acceptable theshold rate of two times that of cupro-nickel 5-cent (see graph above). During this initial two days of wear testing, tin/copper plating was worn through to the zinc core. Wear rates moderated as wear testing continued due to increasing edge thickness with wear test duration. Increasing edge thickness served to reduce sliding wear to obverse/reverse designs, reducing weight loss.

Overall Rating: No Go

TPCPZ Quarter-Dollar (Variability)

WEAR AND DURABILITY TESTING (Sep 17 - Oct 1 and Oct 1 - Oct 15, 2013

d by: Uvon Tolbert



Average Weight Loss (per piece):

TPCPZ Round 1 = 13.5 miligrams
TPCPZ Round 2 = 10.5 miligrams
Current 5 Cent = 21.3 miligrams

Durability (Edge Deformation):

Ending TPCPZ Edge Thickness = 0.0867" for Round 1 and 0.089" for Round 2
Ending Current 5-cent Edge Thickness = 0.070"
Round 1 Deformation = 0.0867 - 0.070 = **0.0167"** Round 2 Deformation = 0.089 - 0.070 = **0.0190"**

Durability Rating: 5-cent TPCPZ is rated No Go for durability because edge deformation difference between it and the current 5-cent coin from the same wear chamber exceeded the maximum allowable of 0.010". The soft zinc core is judged to be too soft to reliably withstand impacts and handling (i.e., repeated mechanical coins sorting/counting) expected during circulation. Additionally, the tin/copper plating did not prevent breakthrough and exposure of the zinc core during 14-day wear testing.

Wear Rating: 5-cent TPCPZ is rated No Go for wear resistance based on the first 2-day weight loss results. During this initial two days of wear testing, tin/copper plating was worn through to the zinc core. Wear rates moderated as wear testing continued due to increasing edge thickness with wear test duration. Increasing edge thickness served to reduce sliding wear to obverse/reverse designs, reducing overall weight loss.

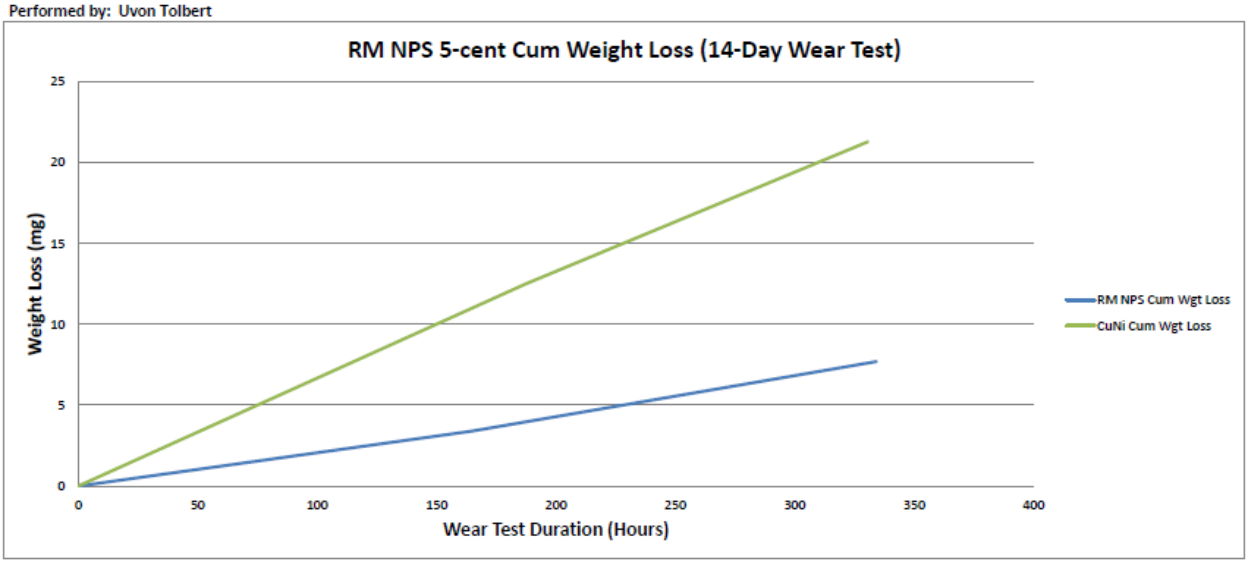
Overall Rating: No Go

10.1.3.NPS

NPS Five-Cent (Variability)

WEAR AND DURABILITY TESTING (Nov 5 - 19, 2013)

Performed by: Uvon Tolbert



Average Weight Loss (per piece): RM NPS 5 cent = 7.7 miligrams
Current 5 cent = 21.3 miligrams

Durability (Edge Deformation): Ending RM NPS 5-cent Edge Thickness = 0.0770"
Ending Current 5-cent Edge Thickness = 0.0790"
Deformation = 0.0770 - 0.0790 = **-0.0020"**

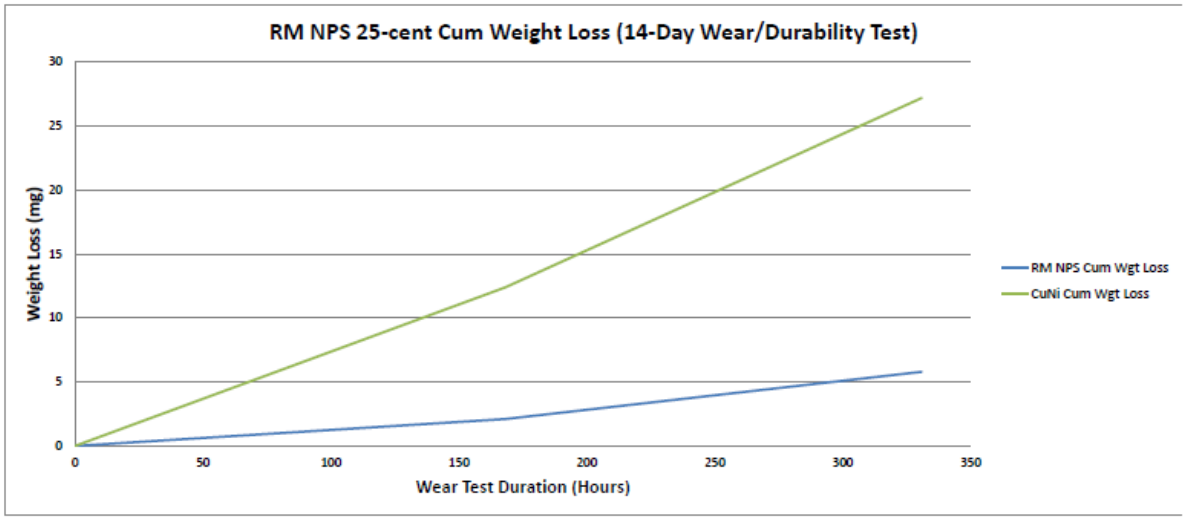
Durability Rating: 5-cent RM NPS rated Go for durability because edge deformation difference between it and the current 5-cent coin from the same wear chamber did not exceed the maximum allowable of 0.010". In fact, MPPS deformation was less than that of the current 5 cent (-0.0020"). This significantly lower deformation is likely due to the relatively thick nickel plating. Nickel plating is much harder than the current cupronickel.

Wear Rating: 5-cent RM NPS is rated Go for wear resistance based on the 14-day weight loss results. The wear rate was not greater than the maximum acceptable theshold rate of two times that of the current 5-cent (see graph above). The wear rate of NPS was significantly less than that of the current 5-cent.

Overall Rating: Go

NPS Quarter-Dollar (Variability)

WEAR AND DURABILITY TESTING



Average Weight Loss (per piece): RM NPS = 5.8 miligrams
Cupro-nickel = 27.2 miligrams

Durability (Edge Deformation): Ending RM NPS Edge Thickness = 0.0695"
Ending Cupro-nickel Edge Thickness = 0.0695"
Deformation = 0.0695 - 0.0695 = 0"

Durability Rating: 25-cent RM NPS rated Go for durability because edge deformation difference between it and cupro-nickel 25-cent coin from the same wear chamber did not exceed the maximum allowable of 0.010". NPS deformation was the same as that of cupro-nickel 25-cent.

Wear Rating: 25-cent RM NPS is rated Go for wear resistance based on the 14-day weight loss results. The wear rate was not greater than the maximum acceptable theshold rate of two times that of cupro-nickel 25-cent (see graph above). The wear rate of NPS was significantly less than that of cupro-nickel 25-cent, especially during week one of testing. This reduced wear rate was due to exceptional low wear along reeded edges of nickel plated test pieces.

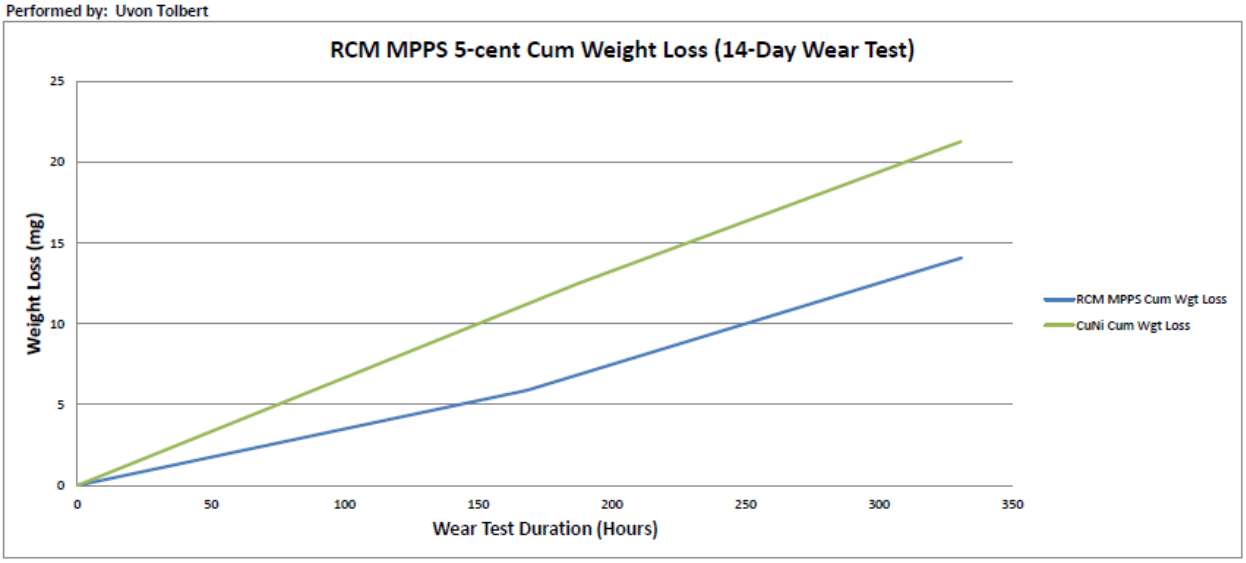
Overall Rating: Go

10.1.4.MPPS

MPPS Five-Cent (Variability)

WEAR AND DURABILITY TESTING (Dec 9 - 23, 2013)

Performed by: Uvon Tolbert



Average Weight Loss (per piece): RCM MPPS = 14.1 miligrams
Current 5 Cent = 21.3 miligrams

Durability (Edge Deformation): Ending RCM MPPS Edge Thickness = 0.0795"
Ending Current 5-cent Edge Thickness = 0.0800"
Deformation = 0.0795 - 0.0810 = **-0.0005"**

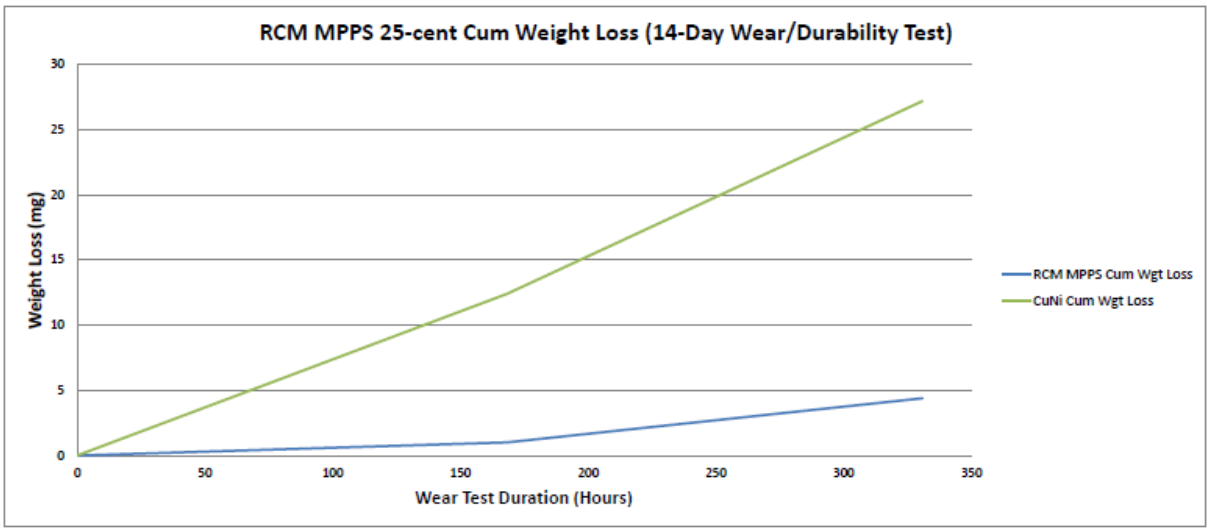
Durability Rating: 5-cent RCM MPPS rated Go for durability because edge deformation difference between it and current 5-cent coin from the same wear chamber did not exceed the maximum allowable of 0.010". In fact, MPPS deformation was less than that of the current 5 cent (-0.0005").

Wear Rating: 5-cent RCM MPPS is rated Go for wear resistance based on the 14-day weight loss results. The wear rate was not greater than the maximum acceptable theshold rate of two times that of the current 5-cent (see graph above). The wear rate of MPPS was significantly less than that of the current 5-cent.

Overall Rating: Go

MPPS Quarter-Dollar (Variability)

WEAR AND DURABILITY TESTING



Average Weight Loss (per piece): RCM MPPS = 4.4 miligrams
Cupro-nickel = 27.2 miligrams

Durability (Edge Deformation): Ending RCM MPPS Edge Thickness = 0.0740"
Ending Cupro-nickel Edge Thickness = 0.0690"
Deformation = 0.0795 - 0.0810 = 0.0050"

Durability Rating: 25-cent RCM MPPS rated Go for durability because edge deformation difference between it and cupro-nickel 25-cent coin from the same wear chamber did not exceed the maximum allowable of 0.010". MPPS deformation was 0.0050" greater than that of cupro-nickel 25-cent.

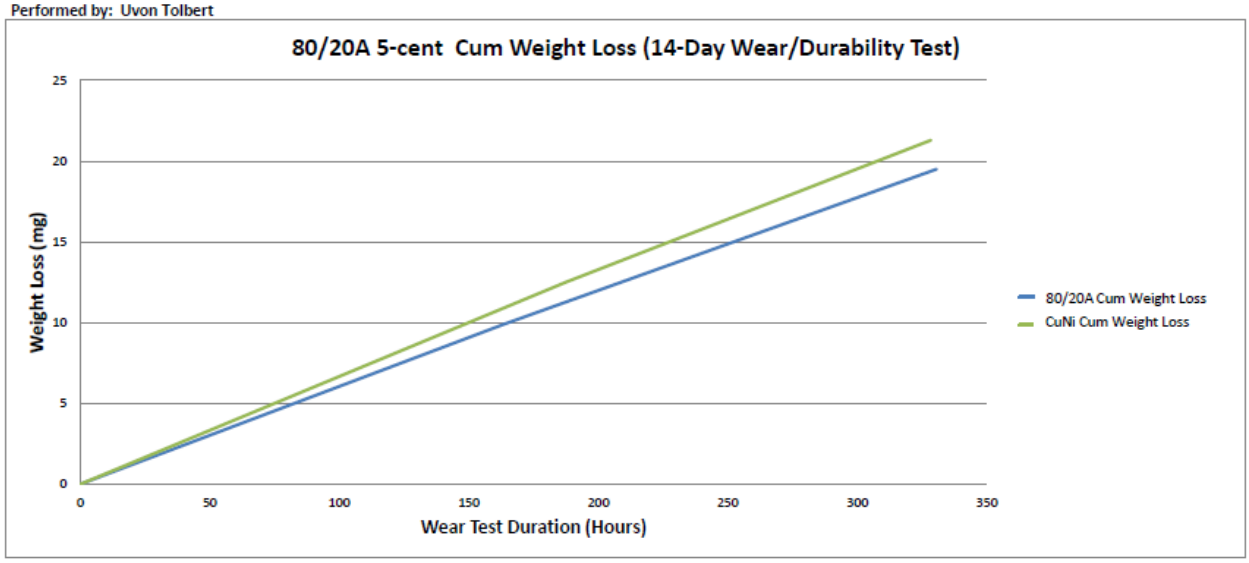
Wear Rating: 25-cent RCM MPPS is rated Go for wear resistance based on the 14-day weight loss results. The wear rate was not greater than the maximum acceptable theshold rate of two times that of cupro-nickel 25-cent (see graph above). The wear rate of MPPS was significantly less than that of cupro-nickel 25-cent, especially during week one of testing. This reduced wear rate was due to exceptional low wear along reeded edges of nickel plated test pieces.

Overall Rating: Go

10.1.5.80/20A (Variability)

WEAR AND DURABILITY TESTING (Oct 15 - Oct 29, 2013)

Performed by: Uvon Tolbert



Average Weight Loss (per piece): 80/20A 5 cent = 19.5 miligrams
Current 5 cent = 21.3 miligrams

Durability (Edge Deformation): Ending 80/20A 5-cent Edge Thickness = 0.0800"
Ending Current 5-cent Edge Thickness = 0.0795"
Deformation = 0.0800 - 0.0795 = **0.0005"**

Durability Rating: 5-cent 80/20A rated Go for durability because edge deformation difference between it and the current 5-cent coin from the same wear chamber did not exceed the maximum allowable of 0.010".

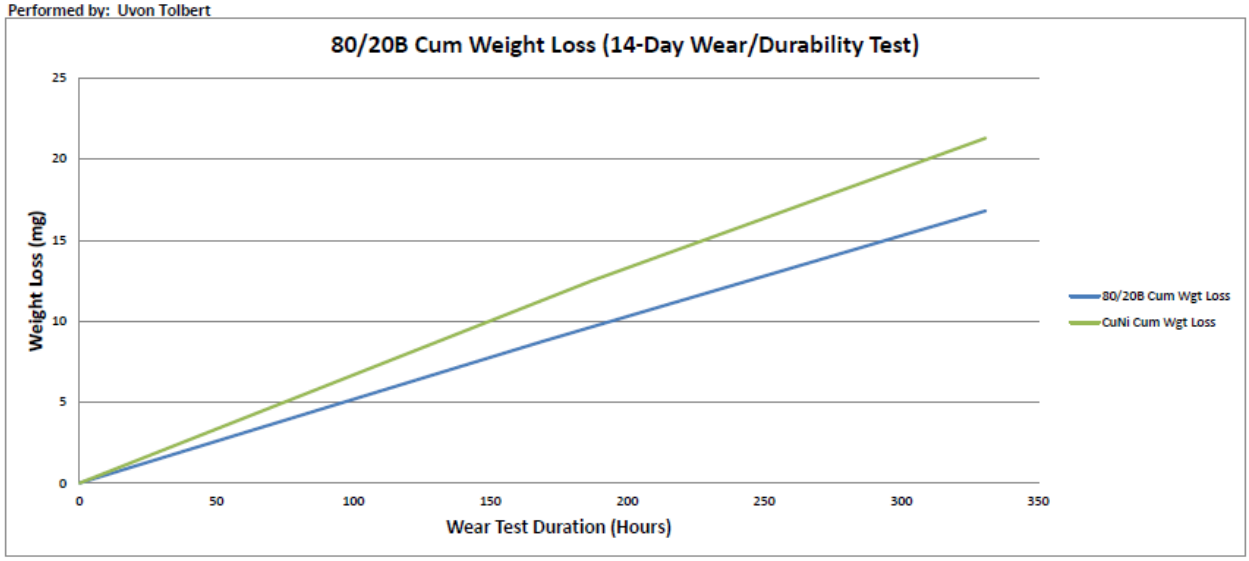
Wear Rating: 5-cent 80/20A is rated Go for wear resistance based on the 14-day weight loss results. The wear rate was not greater than the maximum acceptable theshold rate of two times that of the current 5 cent (see graph above). In fact, the wear rates of 80/20A was comparable to that of the current 5 cent.

Overall Rating: Go

10.1.6.80/20B (Variability)

WEAR AND DURABILITY TESTING (Dec 9 - 23, 2013)

Performed by: Uvon Tolbert



Average Weight Loss (per piece): 80/20B 5 Cent = 16.8 miligrams
Current 5 Cent = 21.3 miligrams

Durability (Edge Deformation): Ending 80/20B 5-cent Edge Thickness = 0.0810"
Ending Current 5-cent Edge Thickness = 0.0820"
Deformation = 0.0820 - 0.0810 = **0.0010"**

Durability Rating: 5-cent 80/20B rated Go for durability because edge deformation difference between it and the current 5-cent coin from the same wear chamber did not exceed the maximum allowable of 0.010".

Wear Rating: 5-cent 80/20B is rated Go for wear resistance based on the 14-day weight loss results. The wear rate was not greater than the maximum acceptable theshold rate of two times that of the current 5-cent (see graph above). The wear rates of 80/20B was less than that of the current 5-cent.

Overall Rating: Go

10.2. Steam Test Results – Variability Lots

10.2.1.CPZ Steam Test

CPZ 5 Cent Blanks Variability Tests Color Change Before and After Steam Test

Test Date: 04/01/14
Operator: Tony Ying
The average measured values of 5 CPZ 5 cent blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the envelope. The standard deviations of the measurement are also listed in the same table.

Table 1: The average and deviation of CPZ blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	76.20	17.29	22.31	1.30	0.94	0.92
After steam test	60.18	26.69	37.67	3.03	2.09	2.70

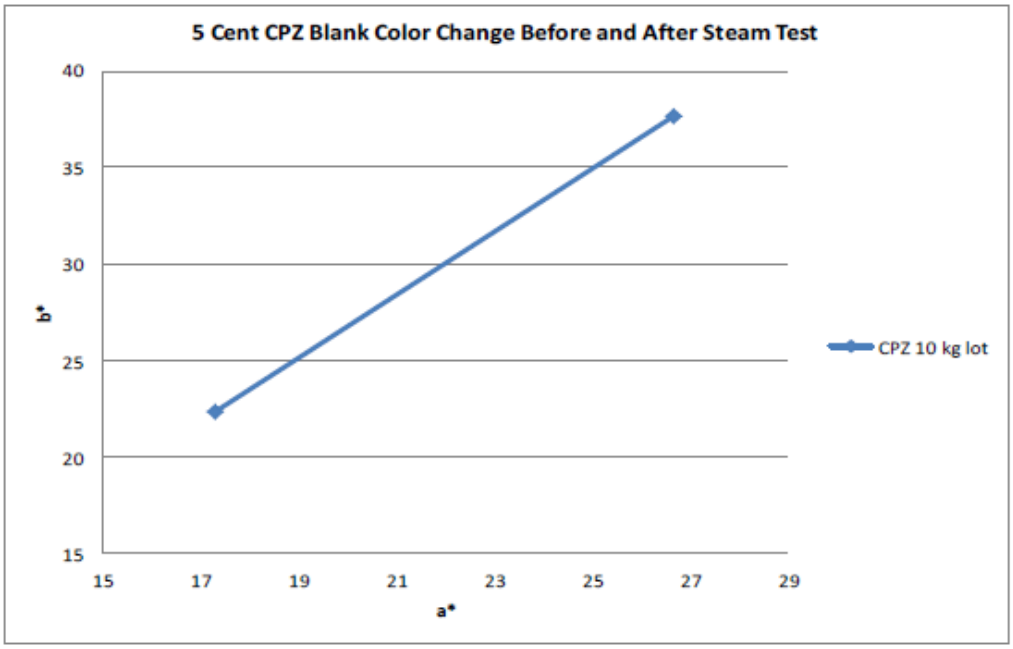


Figure 1: The color change of CPZ blanks.

Overall Assessment: When the other batch of the blanks was tested, the color change was much less. No conclusion was made.

10.2.2.TPCPZ Steam Test

TPCPZ (Five-Cent) (Variability)

TPCPZ 5 Cent Blanks Variability Tests Color Change Before and After Steam

Test Date: 04/03/14

Operator: Tony Ying

The average measured values of 5 TPCPZ 5-cent blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the envelope. The standard deviations of the measurement are also listed in the same table.

Table 1: The average and deviation of TPCPZ 5-cent blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	88.10	-0.37	6.51	0.74	0.07	0.59
After steam test	87.90	-0.21	6.48	0.48	0.07	0.38

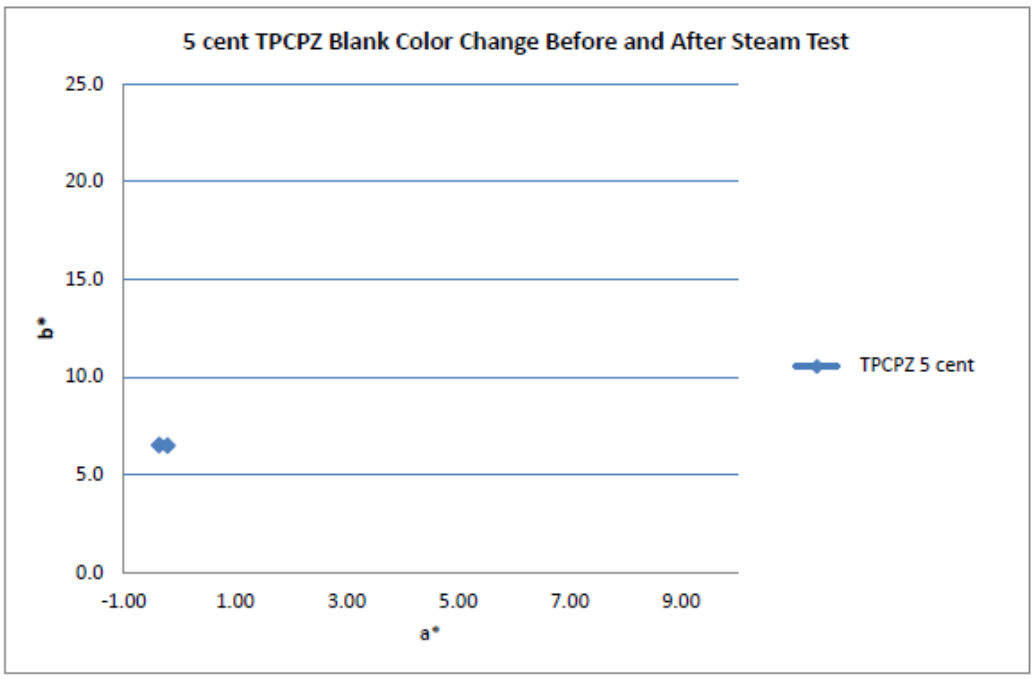


Figure 1: The color change of TPCPZ 5-cent blanks.

Overall Assessment: better than the current cupronickel material.

TPCPZ (Quarter-Dollar) (Variability)

TPCPZ 25 cent blanks Variability Tests Color Change Before and After Steam Test

Test Date: 04/03/14

Operator: Tony Ying

The average measured values of 5 TPCPZ 25-cent blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the envelope. The standard deviations of the measurement are also listed in the same table.

Table 1: The average and deviation of TPCPZ 25-cent blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	87.73	-0.46	6.56	1.78	0.13	0.58
After steam test	88.20	-0.39	6.24	1.06	0.13	0.52

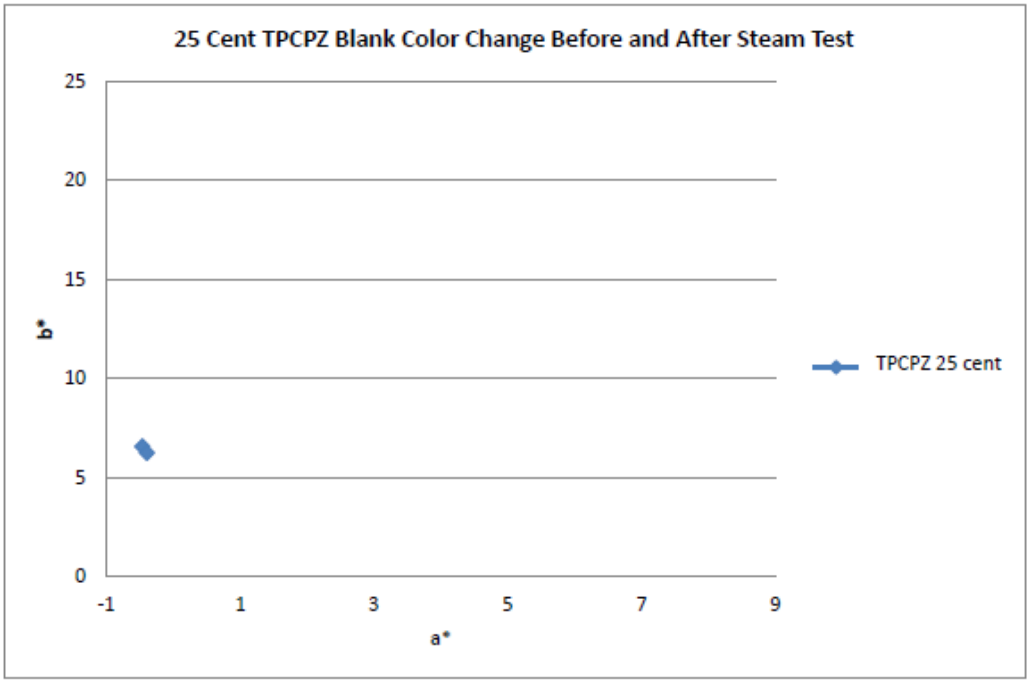


Figure 1: The color change of TPCPZ 25-cent blanks.

Overall Assessment: better than the current cupronickel material.

10.2.3.NPS Steam Test

NPS Five-Cent (Variability)

RM NPS 25 µm 5 Cent Blanks Variability Tests Color Change Before and After Steam Test

Test Date: 04/09/14
Operator: Tony Ying
The average measured values of 5 Royal Mint Nickel Plated Steel 25 µm thick plating layer 5-cent blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the envelope. The standard deviations of the measurement are also listed in the same table. There are three different coating thickness for the nickel plated steel, they are 18 µm, 25 µm, and 32 µm thick, respectively. Since the oxidation only appears on the surface, only 25 µm thick plated samples were tested.

Table 1: The average and deviation of RM NPS 25 µm 25-cent blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	81.65	0.70	7.03	0.54	0.02	0.15
After steam test	79.56	1.04	9.55	1.07	0.12	0.46

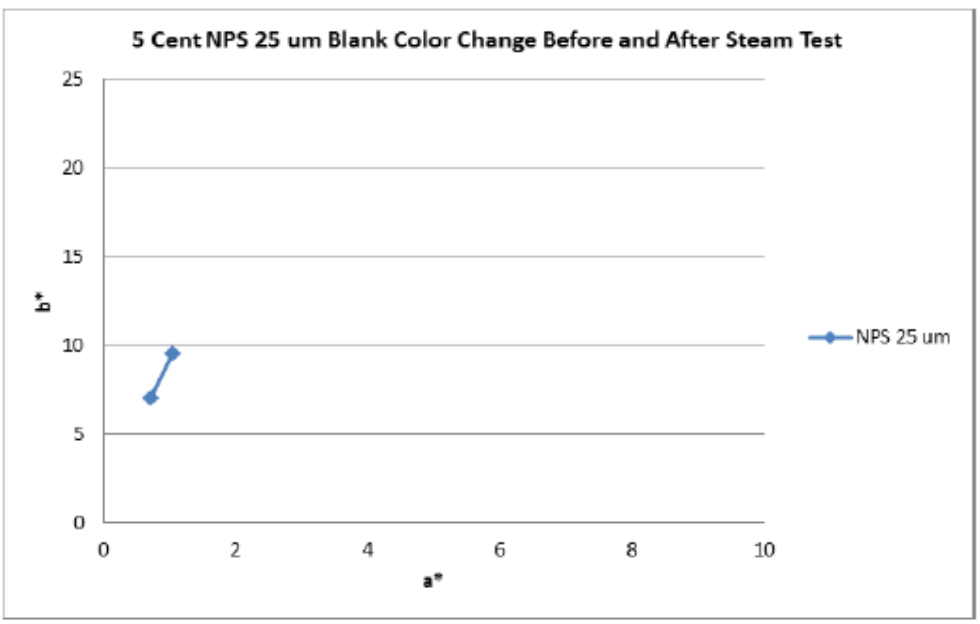


Figure 1: The color change of RM NPS 25 µm 5-cent blanks.

Overall Assessment: better than the incumbent Cupronickel material.

NPS Quarter-Dollar (Variability)

RM NPS 25 µm 25 Cent Blanks Variability Tests Color Change Before and After Steam Test

Test Date: 04/09/14
Operator: Tony Ying
The average measured values of 5 Royal Mint Nickel Plated Steel 25 µm thick plating layer 25-cent blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the envelope. The standard deviations of the measurement are also listed in the same table. There are three different coating thickness for the nickel plated steel, they are 18 µm, 25 µm, and 32 µm thick, respectively. Since the oxidation only appears on the surface, only 25 µm thick plated samples were tested.

Table 1: The average and deviation of RM NPS 25 µm 25-cent blank colors.

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	81.39	0.74	7.22	1.17	0.17	0.74
After steam test	79.74	0.99	9.15	1.72	0.25	0.95

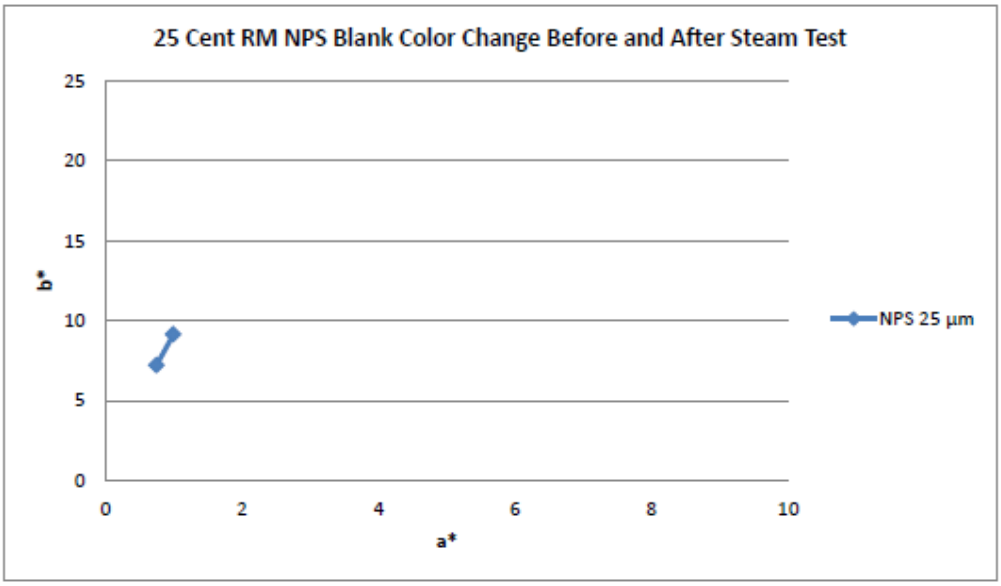


Figure 1: The color change of RM NPS 25 µm 25-cent blanks.

Overall Assessment: better than the incumbent Cupronickel material.

10.2.4.MPPS Steam Test

MPPS Five-Cent (Variability)

RCM MPPS Sample B 5 Cent Blanks Variability Tests Color Change Before and After Steam Test

Test Date: 04/17/14

Operator: Tony Ying

The average measured values of 5 Royal Canadian Mint Multi-Plyl Plated Steel sample B 5-cent blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the envelope. The standard deviations of the measurement are also listed in the same table. There are three different coating thickness for the multi-ply plated steel, they are sample A, B and C, respectively. Since the oxidation only appears on the surface, only sample B was tested.

Table 1: The average and deviation of RCM MPPL Sample B 5-cent blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	78.45	1.05	8.71	0.96	0.10	0.53
After steam test	77.96	1.14	9.58	0.21	0.05	0.46

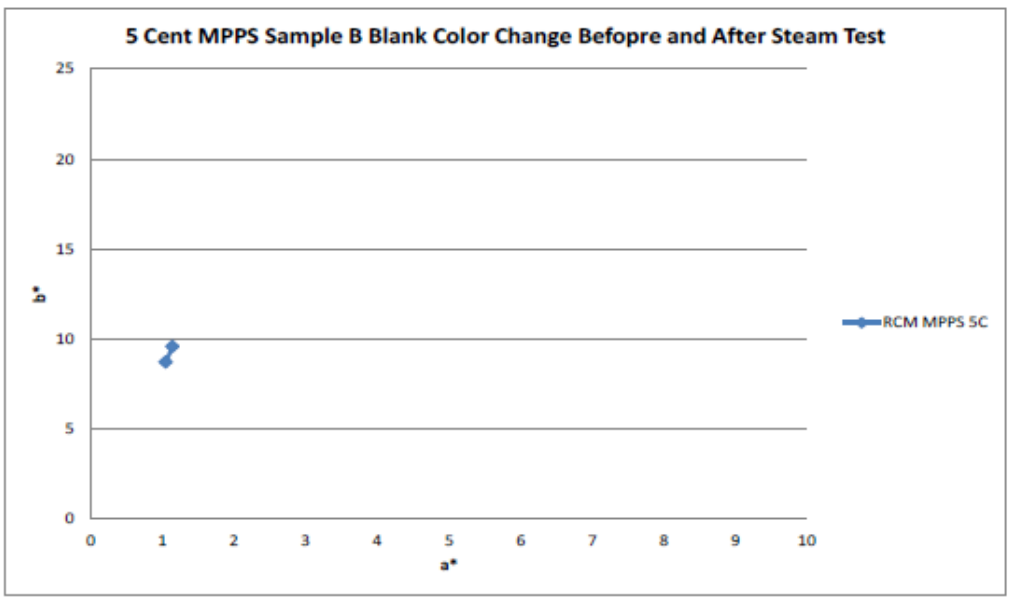


Figure 1: The color change of RCM MPPS sample B 5-cent blanks.

Overall Assessment: better than the incumbent Cupronickel material.

MPPS Quarter-Dollar (Variability)

RCM MPPS Sample B 25 Cent Blanks Variability Tests Color Change Before and After Steam Test

Test Date: 04/17/14

Operator: Tony Ying

The average measured values of 5 Royal Canadian Mint Multi-Plyl Plated Steel sample B 25-cent blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the envelope. The standard deviations of the measurement are also listed in the same table. There are three different coating thickness for the multi-ply plated steel, they are sample A, B and C, respectively. Since the oxidation only appears on the surface, only sample B was tested.

Table 1: The average and deviation of RCM MPPL Sample B 25-cent blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	77.14	1.27	9.71	1.41	0.17	0.76
After steam test	77.13	1.25	9.52	1.12	0.16	0.34

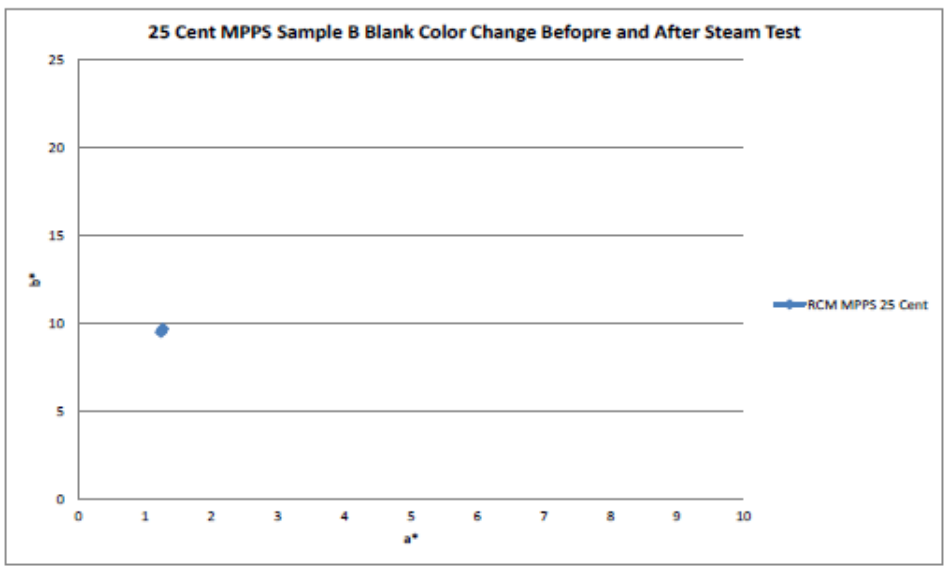


Figure 1: The color change of RCM MPPS sample B 25-cent blanks.

Overall Assessment: better than the incumbent Cupronickel material.

10.2.5.80/20A Steam Test (Variability)

80/20A Cupronickel 5 Cent Blanks Variability Tests Color Change Before and After Steam Test

Test Date: 04/09/14

Operator: Tony Ying

The average measured values of 5 80/20A 5-cent cupronickel blanks made by group #1, #2, #3, #4, #5 and #6 alloys before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the envelope. The standard deviations of the measurement are also listed in the same table.

Table 1: The average and deviation of colors of different groups of 80/20A 5-cent blanks

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
#1 Before	83.15	1.73	9.24	0.62	0.08	0.65
#1 After	70.88	3.75	26.85	5.58	1.62	9.91
#2 Before	81.65	2.24	11.38	0.84	0.17	0.86
#2 After	77.84	2.75	16.24	1.88	0.45	1.86
#3 Before	82.57	1.70	8.56	0.96	0.17	0.93
#3 After	76.64	2.52	18.03	0.56	0.42	2.05
#4 Before	81.93	1.62	9.12	1.00	0.18	0.89
#4 After	77.23	2.20	16.48	1.04	0.14	2.23
#5 Before	81.80	1.75	9.03	1.32	0.26	0.83
#5 After	73.96	2.93	21.39	2.34	0.66	6.78
#6 Before	82.67	1.33	8.45	0.32	0.04	0.31
#6 After	78.34	1.83	14.86	0.66	0.15	1.32

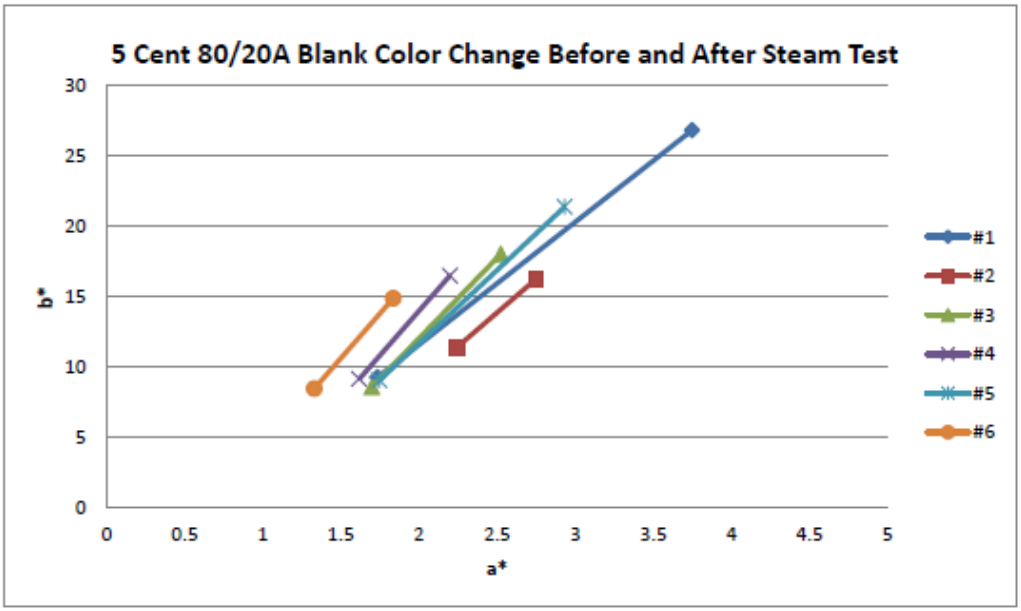


Figure 1: The color change of 6 groups of 80/20A 5-cent blanks.

Overall Assessment: Cannot get conclusion, because large water stain marks randomly appeared on the initial blanks.

10.2.6.80/20B Steam Test (Variability)

80/20B Cupronickel 5 Cent Blanks Variability Tests Color Change Before and After Steam Test

Test Date: 04/10/14

Operator: Tony Ying

The average measured values of 5 80/20B 5-cent cupronickel blanks made by group 81000, 82000, and 83000 alloys before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the envelope. The standard deviations of the measurement are also listed in the same table.

Table 1: The average and deviation of color of different groups of 80/20B 5-cent blanks

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
81000 Before	75.57	1.79	7.86	2.87	0.20	0.94
81000 After	70.54	3.30	16.57	3.41	0.63	2.13
82000 Before	76.17	2.23	9.38	1.92	0.11	0.66
82000 After	68.33	3.29	16.37	4.19	0.63	2.12
83000 Before	76.97	1.64	7.93	1.23	0.20	0.70
83000 After	64.47	3.50	19.18	4.56	1.41	3.71

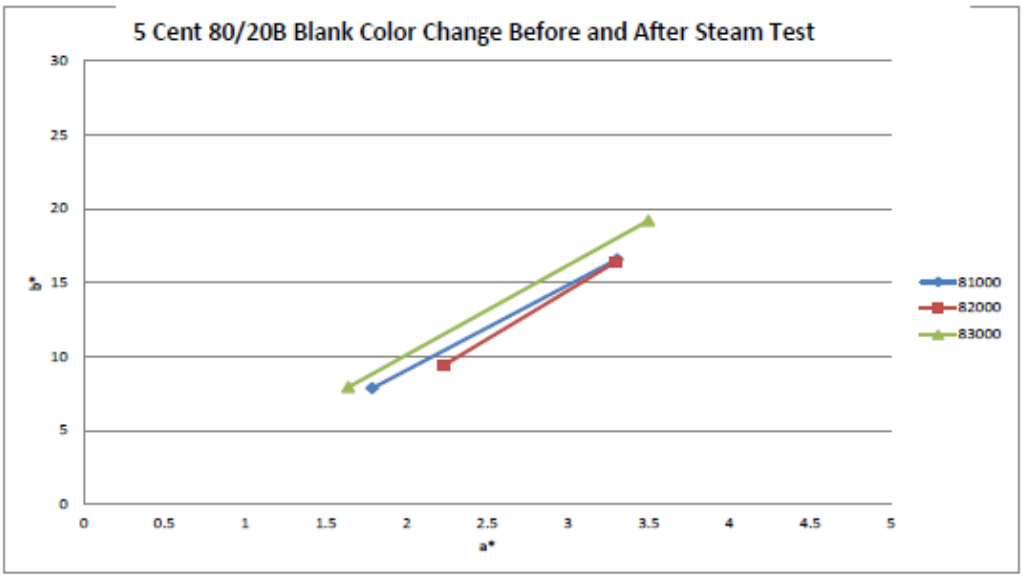


Figure 1: The color change of 3 groups of 80/20B 5-cent blanks.

Overall Assessment: Cannot get conclusion, because large water stain marks randomly appeared on the initial blanks.

10.3. Conductivity and CSV Test Results – Variability Lots

10.3.1.CPZ Conductivity and CSV

Conductivity – Nominal CPZ (Variability)

Electrical Conductivity (% IACS)

Date:	4-Feb-14	**Page _1_of_1__**
Conductivity Meter:	Sigma Test D 2.068 Foerster (Cert: 20130200-51386) Due March 25, 2014	
Operator:	Barry Claybrook	
Material:	CPZ 5c Nominal Plating	
Form:	Planchets (10 Kg)	

	FREQUENCY			
	1 = ___60__kHz	**2 = __120__kHz**	**3 = __240__kHz**	**4 = __480__kHz**
1	28.47	28.62	28.93	29.21
2	28.41	28.64	28.930	29.28
3	28.43	28.53	28.97	29.34
4	28.380	28.64	28.930	29.22
5	28.47	28.62	28.91	29.24
6	28.410	28.590	28.970	29.22
7	28.36	28.59	28.86	29.31
8	28.43	28.55	28.88	29.24
9	28.450	28.66	28.97	29.26
10	28.45	28.64	28.91	29.47
11	28.48	28.69	28.95	29.36
12	28.47	28.64	29	29.26
13	28.450	28.660	28.910	29.19
14	28.47	28.66	29	29.47
15	28.5	28.67	28.95	29.36
16	28.47	28.69	29.02	29.55
17	28.47	28.72	28.78	29.33
18	28.48	28.66	28.86	29.20
19	28.4	28.62	28.97	29.34
20	28.450	28.640	28.900	29.34
Average	**28.45**	**28.64**	**28.93**	**29.31**
Median	**28.45**	**28.64**	**28.93**	**29.30**
SD	**0.037**	**0.046**	**0.057**	**0.099**
Min	**28.36**	**28.53**	**28.78**	**29.19**
Max	**28.50**	**28.72**	**29.02**	**29.55**

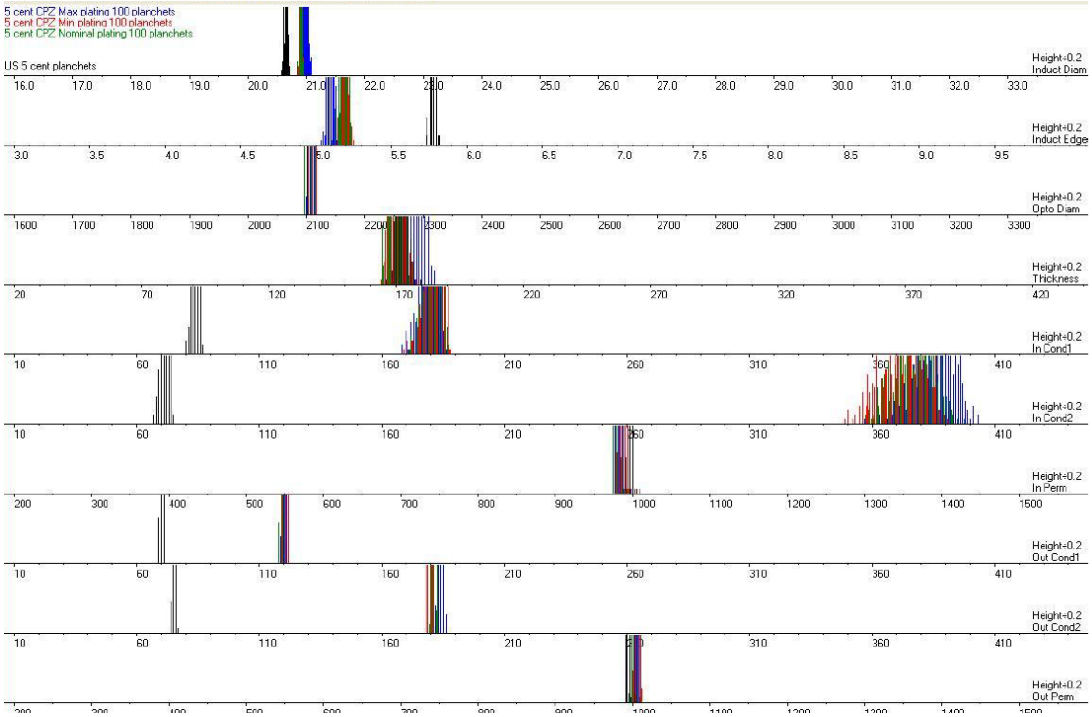
Conductivity – Min CPZ (Variability)

Electrical Conductivity (% IACS)

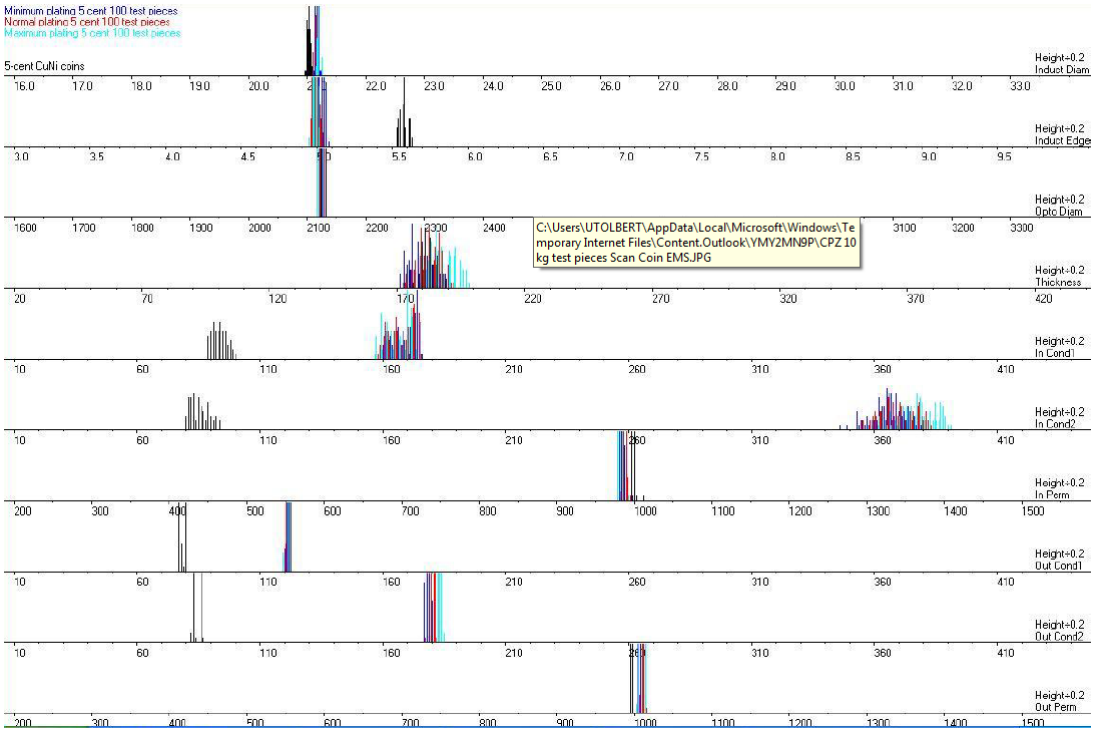
Date:	4-Feb-14	**Page _1_of_1__**
Conductivity Meter:	Sigma Test D 2.068 Foerster (Cert: 20130200-51386) Due March 25, 2014	
Operator:	Barry Claybrook	
Material:	CPZ 5c Minimum Plating	
Form:	Planchets (10 Kg)	

	FREQUENCY			
	1 = _____60__kHz	**2 = ____120__kHz**	**3 = ____240__kHz**	**4 = ___480__kHz**
1	28.17	28.22	28.53	28.83
2	28.02	28.22	28.450	28.79
3	28.12	28.29	28.48	28.79
4	28.000	28.21	28.500	28.76
5	28.12	28.26	25.5	28.84
6	28.120	28.240	28.520	28.86
7	28.12	28.31	28.53	28.72
8	28.22	28.22	28.57	28.76
9	28.170	28.28	28.57	28.84
10	28.12	28,28	28.56	28.78
11	28.21	28.24	28.5	28.76
12	28.21	28.31	28.53	28.74
Average	**28.13**	**28.25**	**28.25**	**28.79**
Median	**28.12**	**28.24**	**28.52**	**28.79**
SD	**0.069**	**0.034**	**0.912**	**0.044**
Min	**28**	**28.21**	**25.5**	**28.72**
Max	**28.22**	**28.31**	**28.57**	**28.86**

CSV –Planchet CPZ (Variability)



CSV – Coin CPZ (Variability)



10.3.2.TPCPZ Conductivity and CSV

Conductivity – Max TPCPZ (Five-Cent) (Variability)

Electrical Conductivity (% IACS)

Date:	4-Feb-14	**Page _1_of_1__**
Conductivity Meter:	Sigma Test D 2.068 Foerster (Cert: 20130200-51386) Due March 25, 2014	
Operator:	Barry Claybrook	
Material:	TPCPZ 5c Horizontal Max Plating	
Form:	Planchets (10 Kg)	

	FREQUENCY			
	1 = _____60__kHz	**2 = ____120__kHz**	**3 = ____240__kHz**	**4 = ___480__kHz**
1	28.53			30.57
2	28.55			30.38
3	28.59			30.4
4	28.6			30.64
5	28.53			30.38
6	28.62			30.53
7	28.55			30.31
8	28.5			30.71
9	28.53			30.55
10	28.62			30.43
11				
Average	**28.56**			**30.49**
Median	**28.55**			**30.48**
SD	**0.042**			**0.129**
Min	**28.5**			**30.31**
Max	**28.62**			**30.71**

Conductivity – Max TPCPZ (Quarter-Dollar) (Variability)

Electrical Conductivity (% IACS)

Date:	4-Feb-14	**Page _1_of_1__**
Conductivity Meter:	Sigma Test D 2.068 Foerster (Cert: 20130200-51386) Due March 25, 2014	
Operator:	Barry Claybrook	
Material:	TPCPZ 25c Horizontal Max Plating	
Form:	Planchets (10 Kg)	

	FREQUENCY			
	1 = _____60__kHz	**2 = ____120__kHz**	**3 = ____240__kHz**	**4 = ___480__kHz**
1	28.57			30.66
2	28.79			30.6
3	28.71			30.78
4	28.9			30.72
5	28.81			30.38
6	28.84			30.64
7	28.86			30.41
8	28.81			30.64
9	28.74			30.57
10	28.88			30.6
11	28.86			30.64
12				
Average	**28.80**			**30.60**
Median	**28.81**			**30.64**
SD	**0.095**			**0.119**
Min	**28.57**			**30.38**
Max	**28.90**			**30.78**

Conductivity – Nominal TPCPZ (Five-Cent) (Variability)

Electrical Conductivity (% IACS)

Date:	4-Feb-14
Conductivity Meter:	Sigma Test D 2.068 Foerster (Cert: 20130200-51386) Due March 25, 2014
Operator:	Barry Claybrook
Material:	TPCPZ 5c Oblique Nom Plating
Form:	Planchets (10 Kg)

Page _1_of_1__

	FREQUENCY			
	1 = _____60__kHz	**2 = ____120__kHz**	**3 = ____240__kHz**	**4 = ___480__kHz**
1	28.48			30.48
2	28.57			30.4
3	28.53			30.62
4	28.52			30.53
5	28.57			30.76
6	28.59			30.97
7	28.55			30.379
8	28.53			30.78
9	28.55			30.79
10	28.57			30.76
11	28.59			30.57
12				
Average	**28.55**			**30.64**
Median	**28.55**			**30.62**
SD	**0.033**			**0.187**
Min	**28.48**			**30.379**
Max	**28.59**			**30.97**

Conductivity – Nominal TPCPZ (Quarter-Dollar) (Variability)

Electrical Conductivity (% IACS)

Date:	4-Feb-14	**Page _1_of_1__**
Conductivity Meter:	Sigma Test D 2.068 Foerster (Cert: 20130200-51386) Due March 25, 2014	
Operator:	Barry Claybrook	
Material:	TPCPZ 25c Oblique Nom Plating	
Form:	Planchets (10 Kg)	

	FREQUENCY			
	1 = _____60__kHz	**2 = ____120__kHz**	**3 = ____240__kHz**	**4 = ___480__kHz**
1	28.66			29.88
2	28.6			30.41
3	28.57			30.12
4	28.62			30.07
5	28.66			30.21
6	28.72			30.41
7	28.62			30.22
8	28.69			30.17
9	28.66			30.33
10	28.76			30.29
11	28.71			30.31
12				
Average	**28.66**			**30.22**
Median	**28.66**			**30.22**
SD	**0.056**			**0.157**
Min	**28.57**			**29.88**
Max	**28.76**			**30.41**

Conductivity – Min TPCPZ (Five-Cent) (Variability)

Electrical Conductivity (% IACS)

Date:	4-Feb-14
Conductivity Meter:	Sigma Test D 2.068 Foerster (Cert: 20130200-51386) Due March 25, 2014
Operator:	Barry Claybrook
Material:	TPCPZ 5c Horizontal/Oblique Min Plating
Form:	Planchets (10 Kg)

Page _1_of_1__

	FREQUENCY			
	1 = _____60__kHz	**2 = ____120__kHz**	**3 = ____240__kHz**	**4 = ___480__kHz**
1	28.19			29.22
2	28.4			29.12
3	28.38			29.02
4	28.24			29.17
5	28.21			29.12
6	28.38			29.38
7	28.38			29.09
8	28.28			29.14
9	28.34			29.07
10	28.36			29.16
11	28.38			28.98
12	28.33			29.22
13	28.29			29.1
14	28.33			29.22
15	28.36			29.31
16	28.29			29.19
17	28.33			29.1
18	28.34			29.31
19	28.33			29.38
20	28.31			29.4
	28.28			29.31
Average	**28.32**			**29.13**
Median	**28.36**			**29.12**
SD	**0.077**			**0.106**
Min	**28.19**			**28.98**
Max	**28.40**			**29.40**

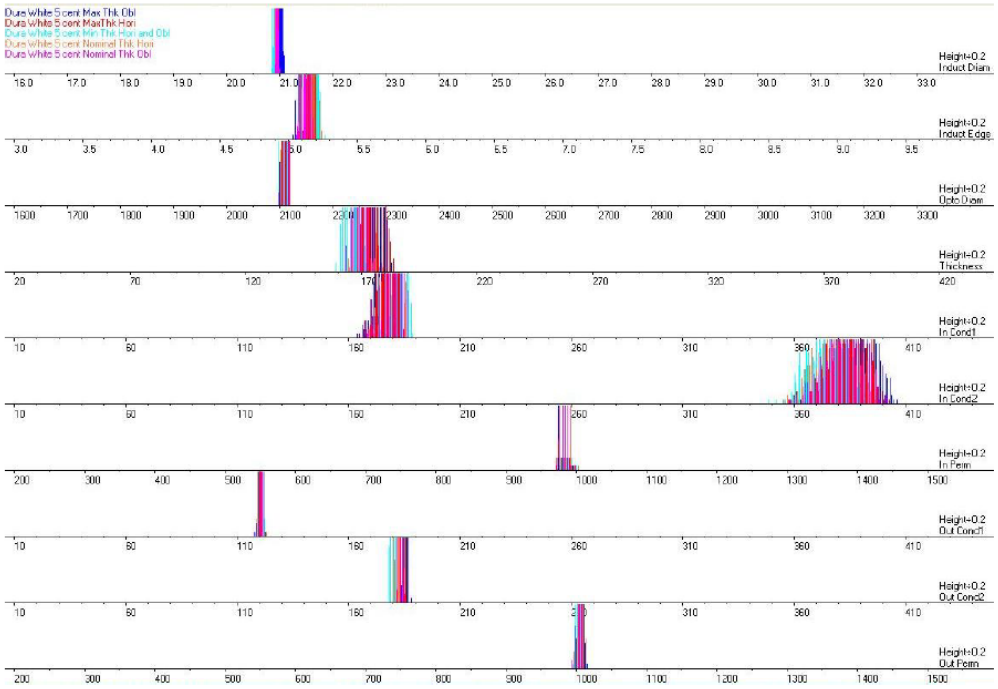
Conductivity – Min TPCPZ (Quarter-Dollar) (Variability)

Electrical Conductivity (% IACS)

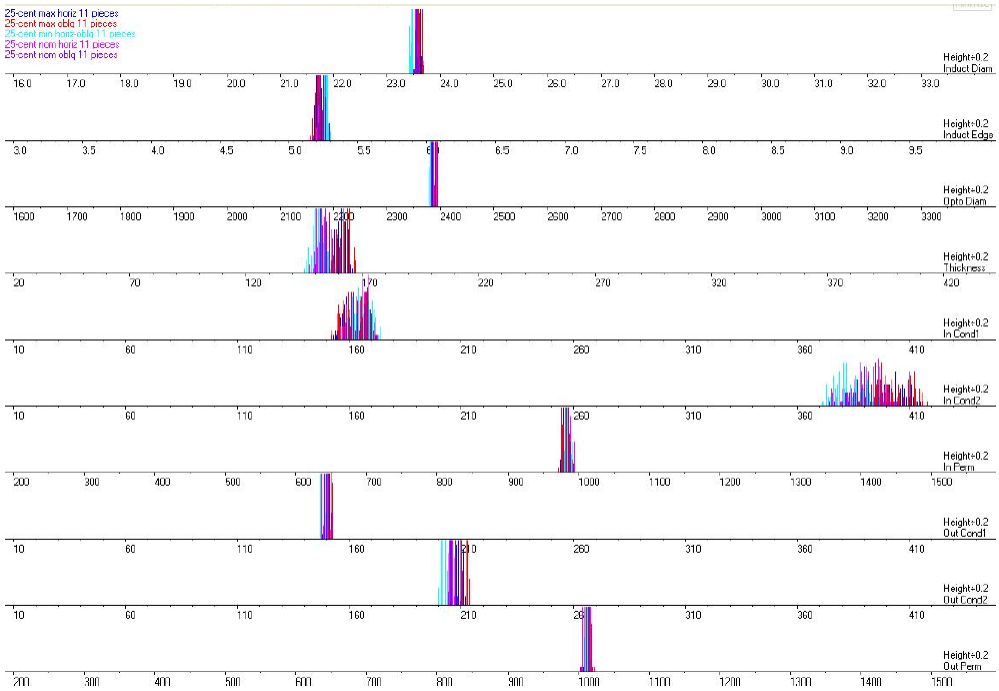
Date:	4-Feb-14	**Page _1_of_1__**
Conductivity Meter:	Sigma Test D 2.068 Foerster (Cert: 20130200-51386) Due March 25, 2014	
Operator:	Barry Claybrook	
Material:	TPCPZ 25c Horizontal/Oblique Min Plating	
Form:	Planchets (10 Kg)	

	FREQUENCY			
	1 = _____60__kHz	**2 = ____120__kHz**	**3 = ____240__kHz**	**4 = ___480__kHz**
1	28.48			29.26
2	28.52			29.22
3	28.62			29.09
4	28.55			29.03
5	28.53			29.14
6	28.59			29.16
7	28.52			29.17
8	28.55			29.34
9	28.6			29.12
10	28.64			29.33
11	28.62			29.38
12				
Average	**28.57**			**29.20**
Median	**28.55**			**29.17**
SD	**0.051**			**0.112**
Min	**28.48**			**29.03**
Max	**28.64**			**29.38**

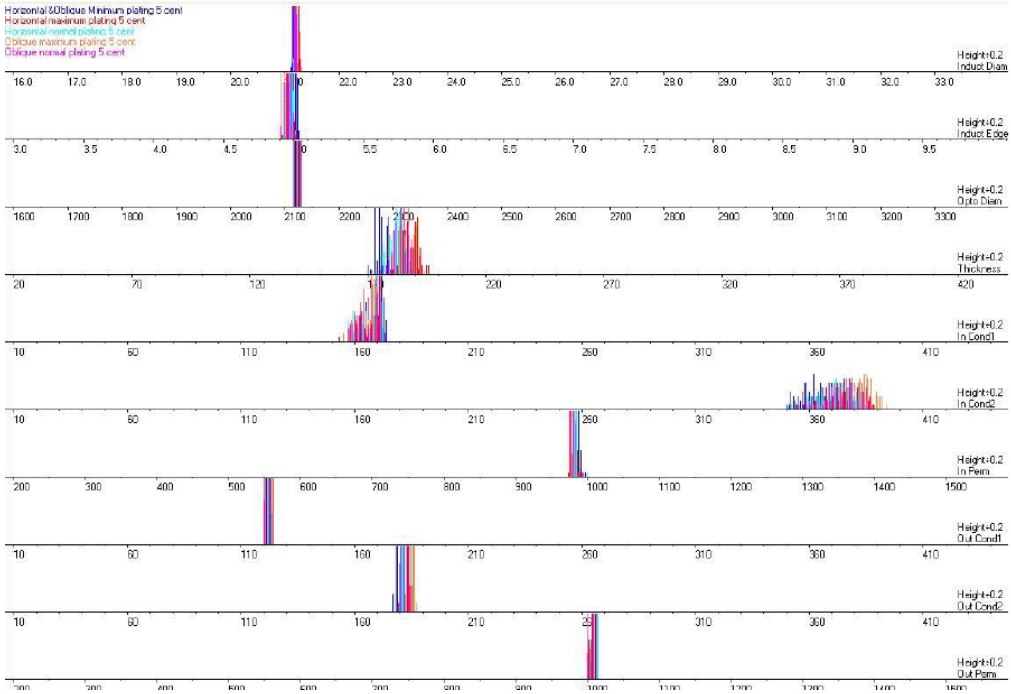
CSV – Planchet TPCPZ (Five-Cent) (Variability)



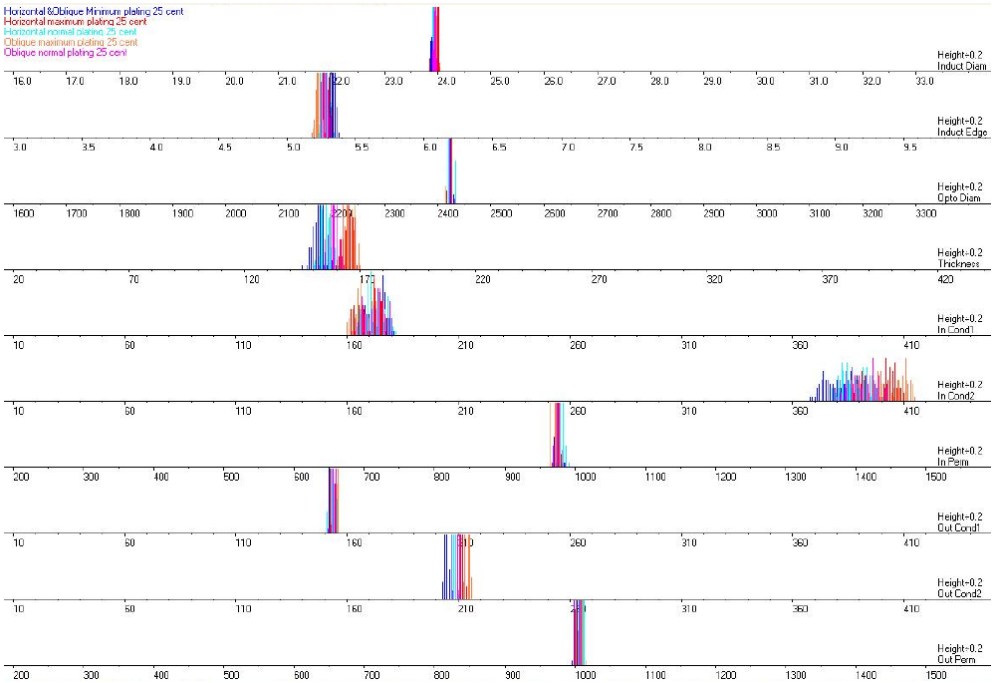
CSV – Planchet TPCPZ (Quarter-Dollar) (Variability)



CSV – Coin TPCPZ (Five-Cent) (Variability)

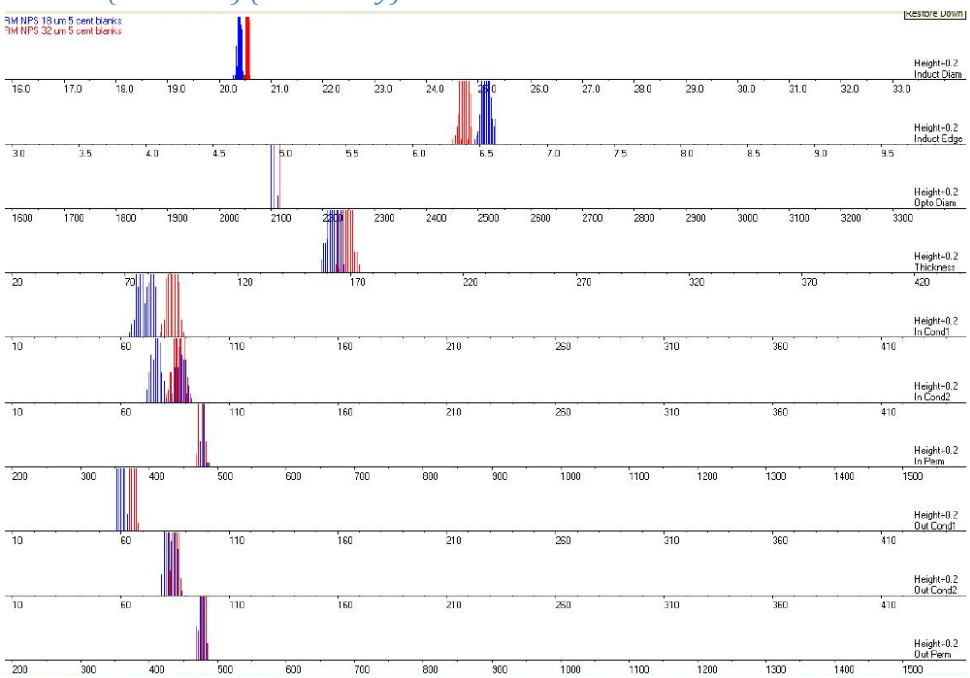


CSV – Coin TPCPZ (Quarter-Dollar) (Variability)

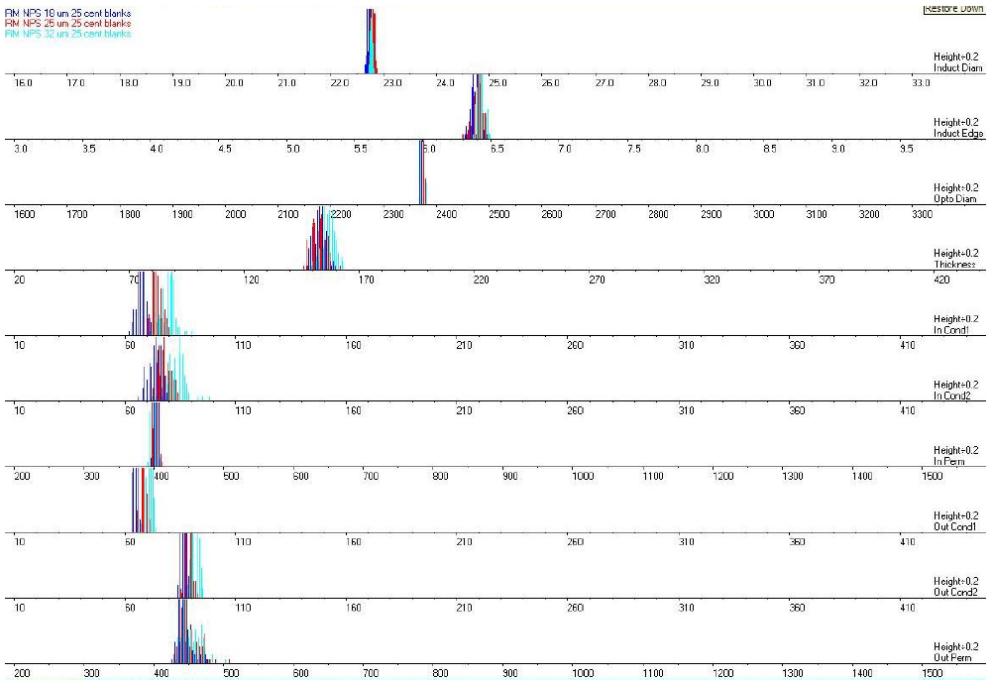


10.3.3.NPS (Conductivity Test Not Applicable)

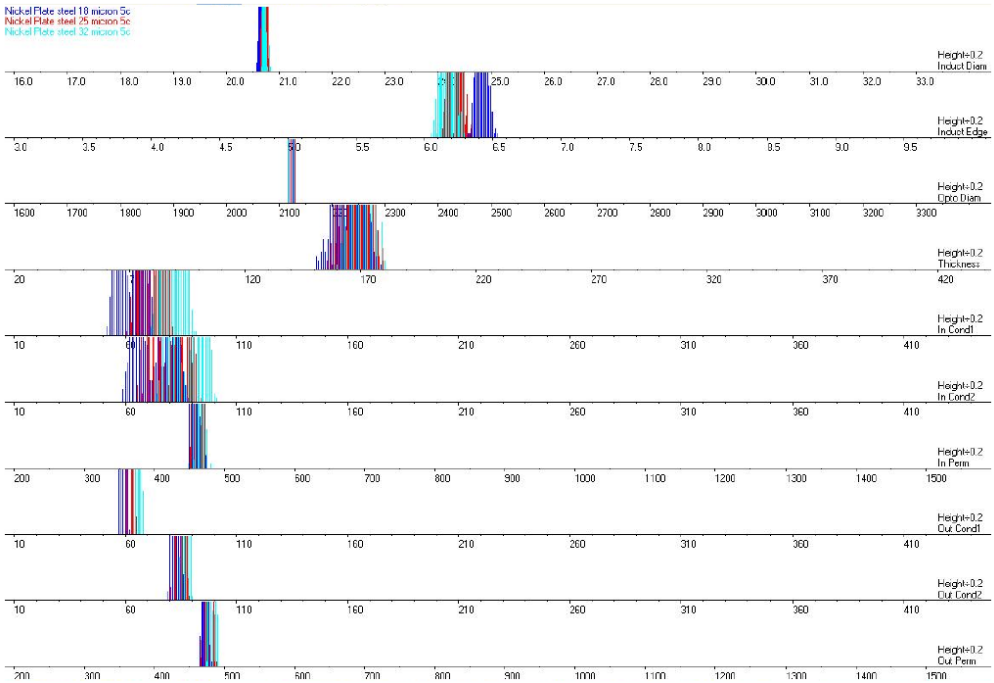
CSV – Planchet NPS (Five-Cent) (Variability)



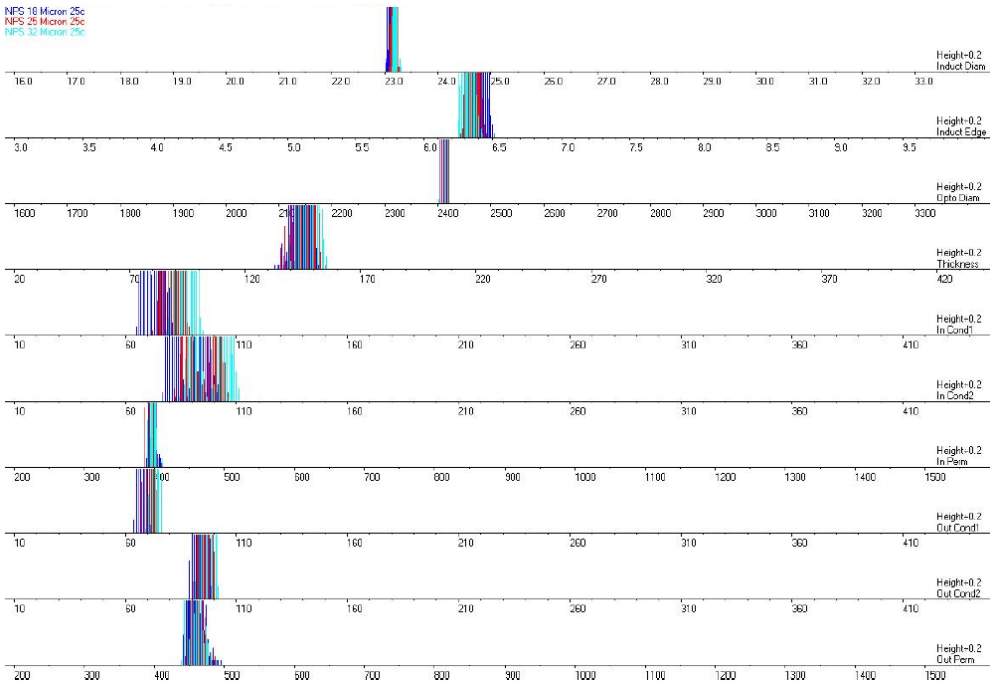
CSV – Planchet NPS (Quarter-Dollar) (Variability)



CSV – Coin NPS (Five-Cent) (Variability)

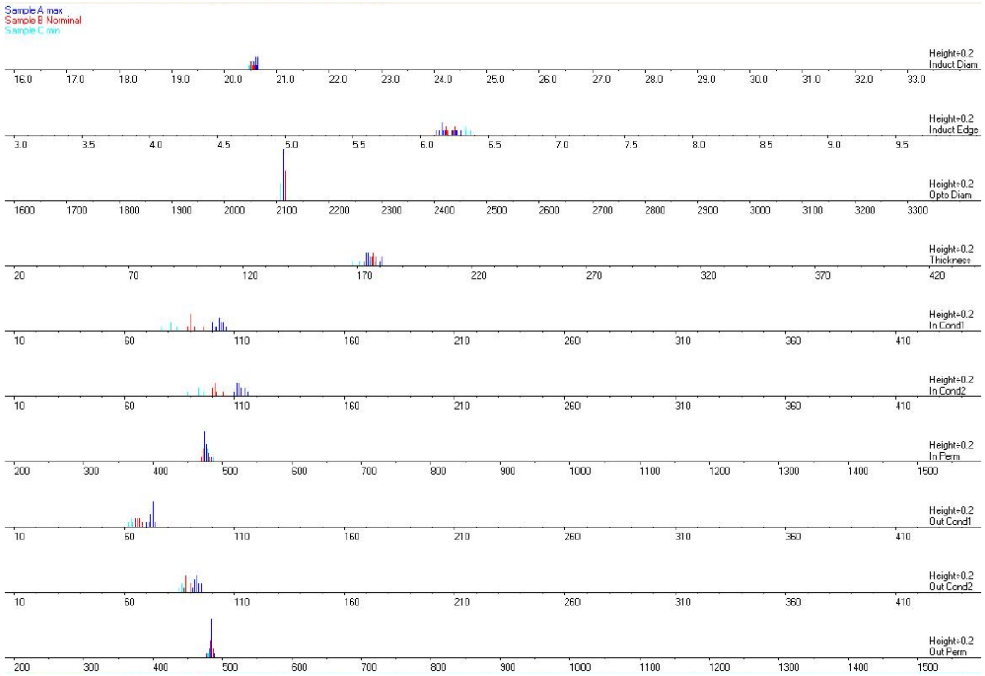


CSV – Coin NPS (Quarter-Dollar) (Variability)

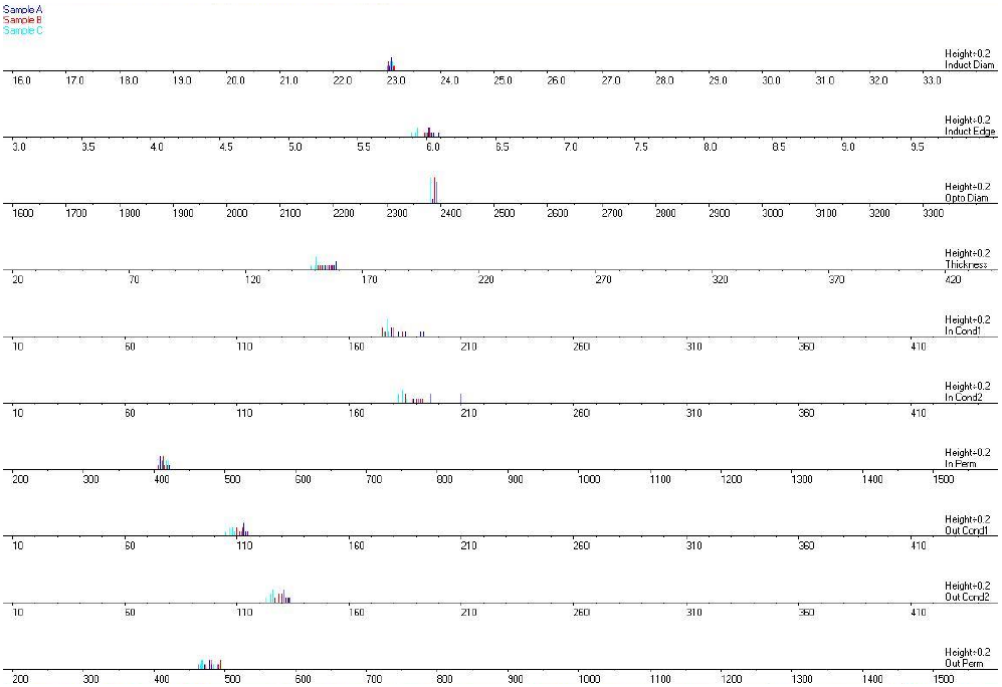


10.3.4.MPPS (Conductivity Test Not Applicable)

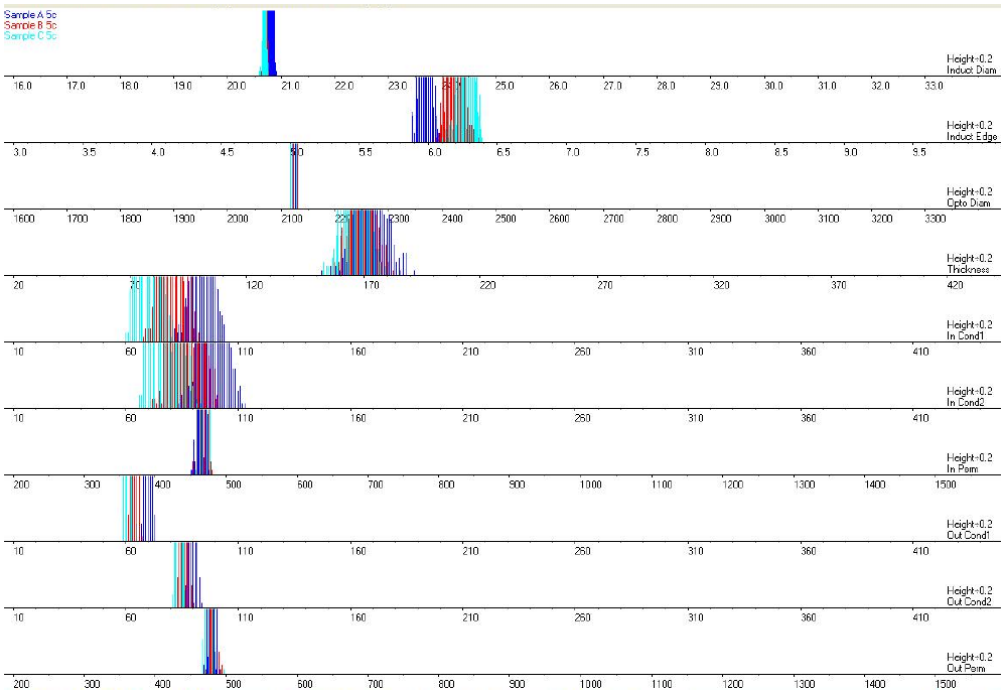
CSV – Planchet MPPS (Five-Cent) (Variability)



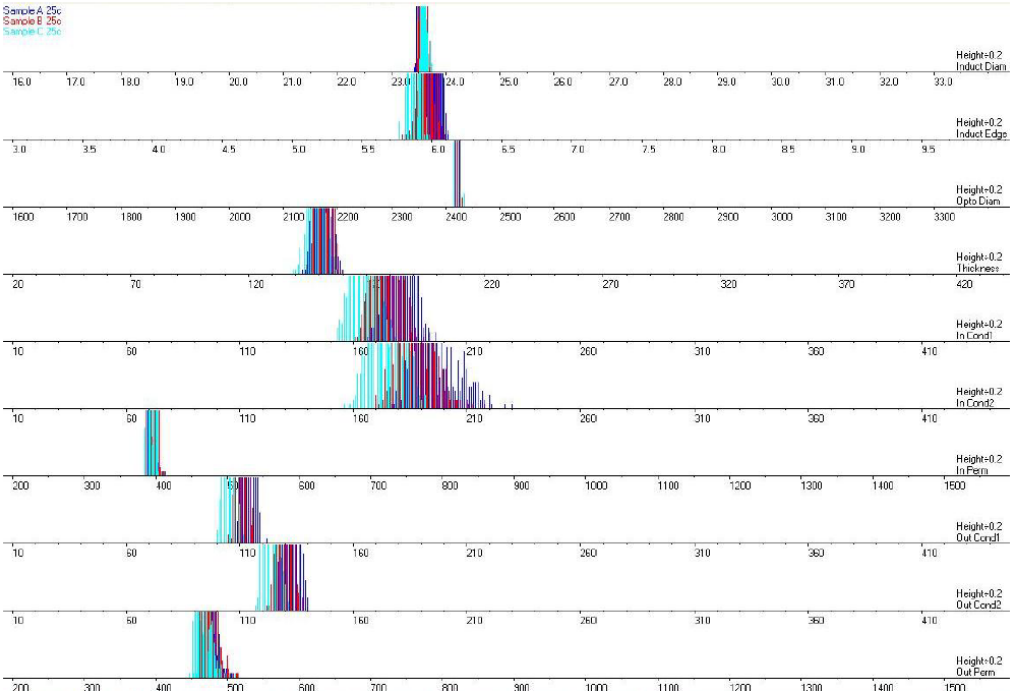
CSV – Planchet MPPS (Quarter-Dollar) (Variability)



CSV – Coin MPPS (Five-Cent) (Variability)

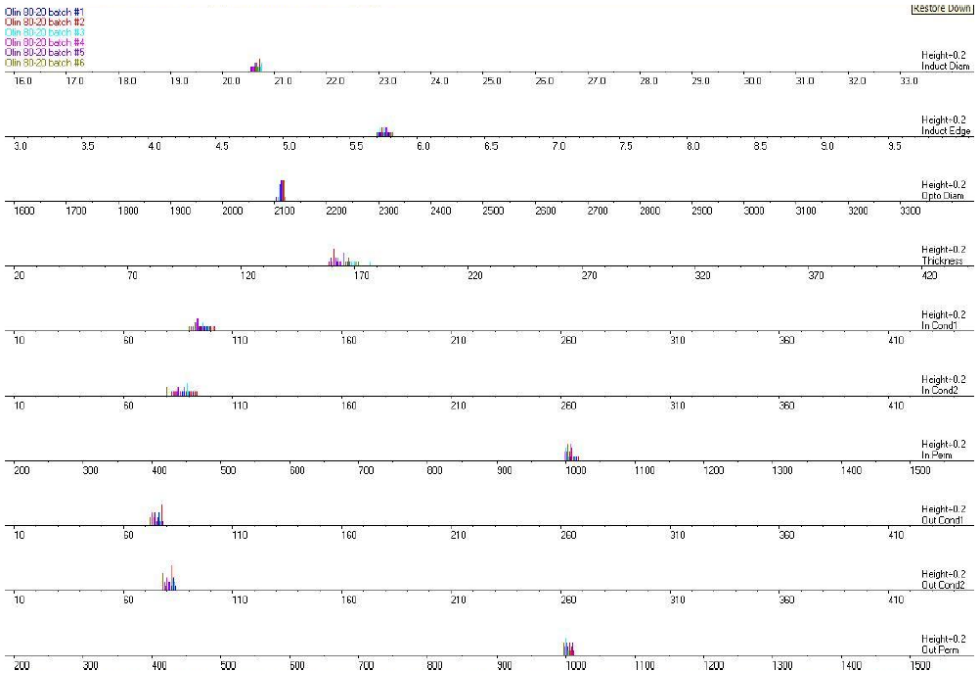


CSV – Coin MPPS (Quarter-Dollar) (Variability)

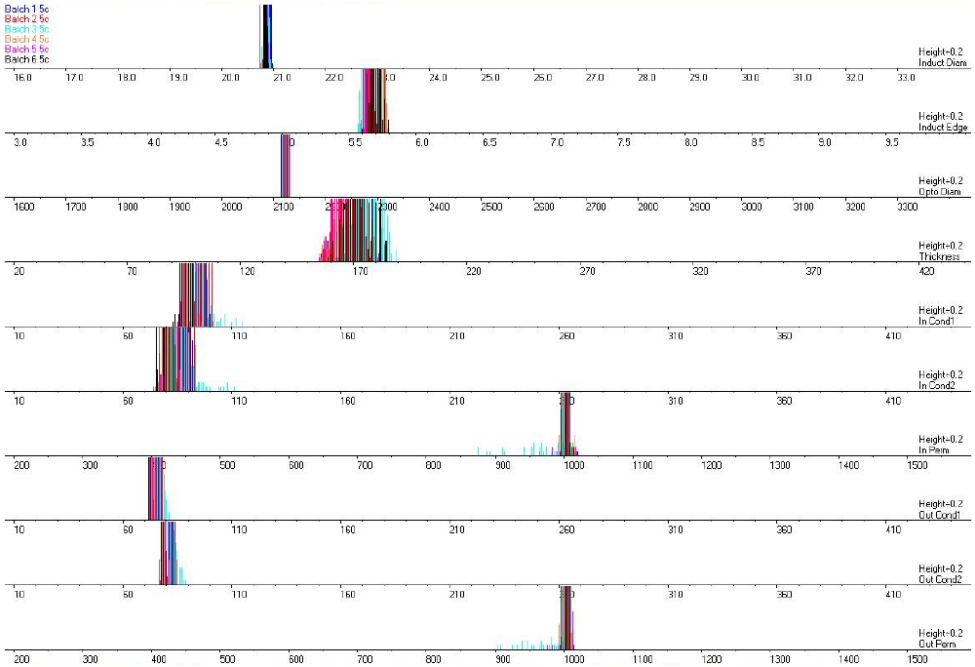


10.3.5.80/20A (Conductivity Results Unavailable)

CSV – Planchet 80/20A (Variability)

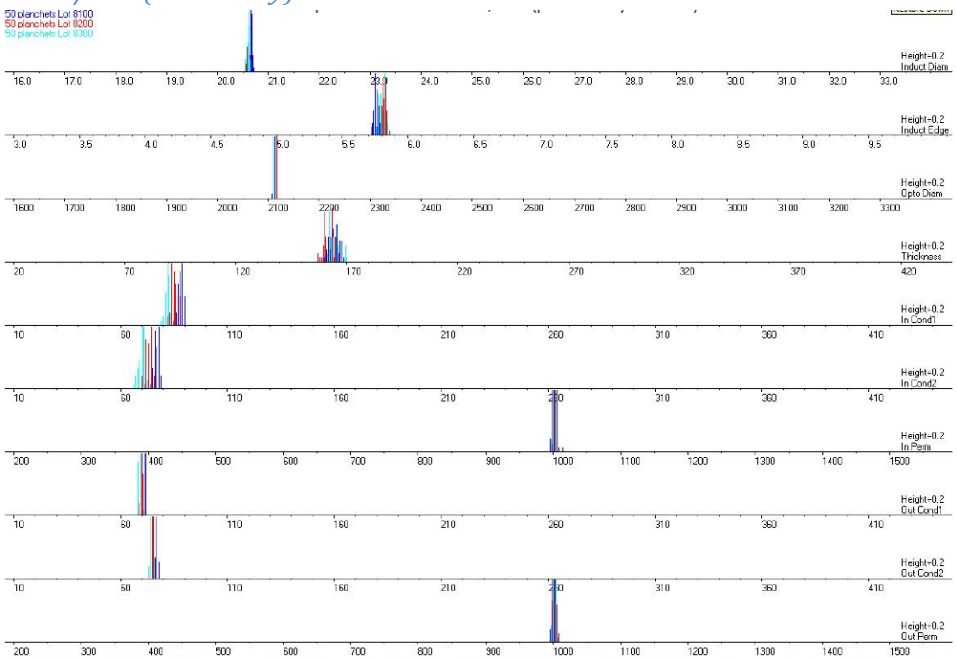


CSV – Coin 80/20A (Variability)

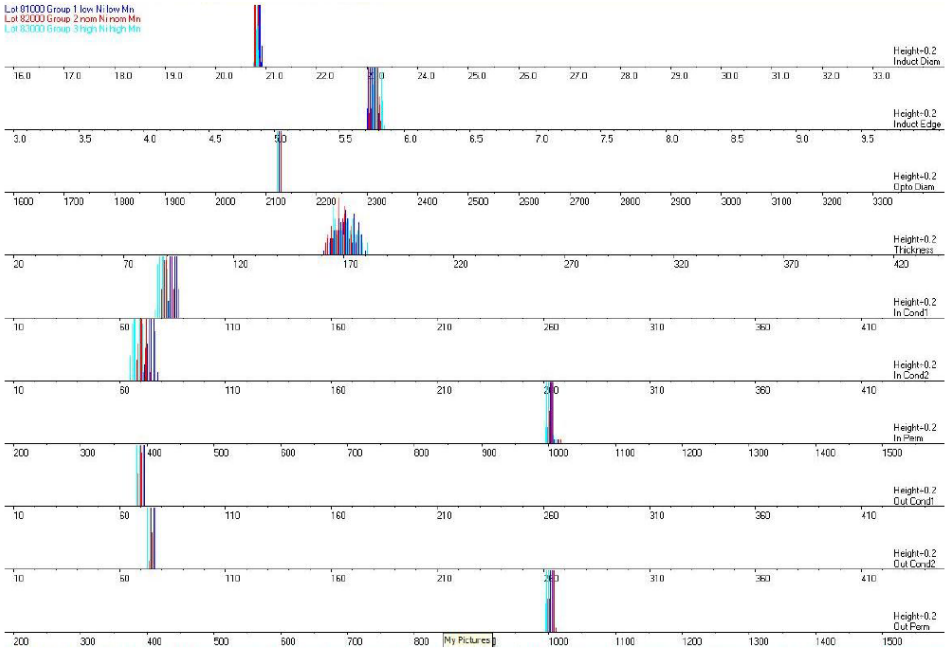


10.3.6.80/20B (Conductivity Results Unavailable)

CSV – Planchet 80/20B (Variability)



CSV – Coin 80/20B (Variability)



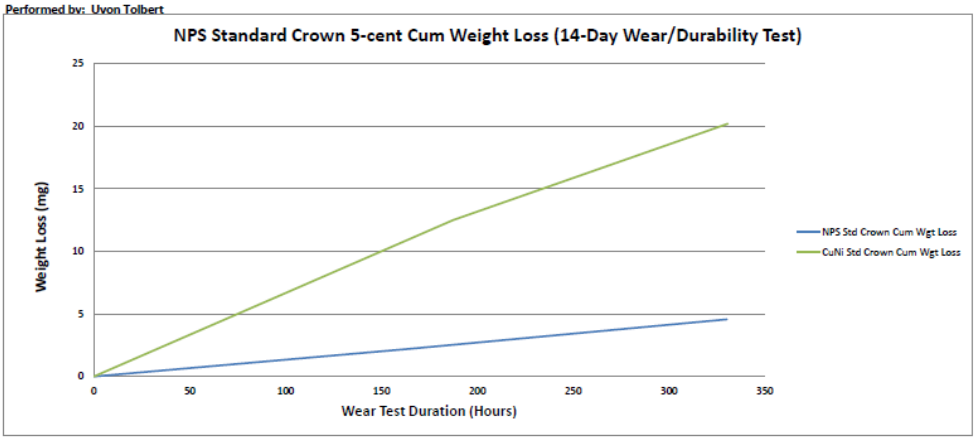
10.4. Wear Test Results – Pre-Production

10.4.1.NPS

NPS Pilot Material (Five-Cent)

WEAR AND DURABILITY TESTING (May 22 - June 5, 2014)

Performed by: Uvon Tolbert



Average Weight Loss (per piece): NPS 5-cent = 4.6 miligrams
Cupro-nickel = 19 miligrams

Durability (Edge Deformation): Ending NPS 5-cent Edge Thickness = 0.0780"
Ending Cupro-nickel Edge Thickness = 0.0820"
Deformation = 0.0780 - 0.0820 = - 0.0040"

Durability Rating: 5-cent NPS 5-cent rated Go for durability because edge deformation difference between it and cupro-nickel 5-cent coin from the same wear chamber did not exceed the maximum allowable of 0.010". In fact, NPS 5-cent demonstrated less deformation than baseline cupro-nickel.

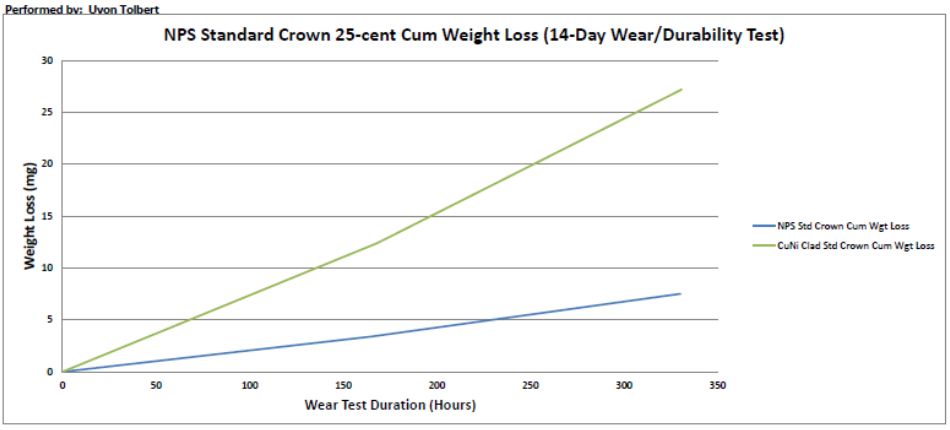
Wear Rating: 5-cent NPS 5-cent is rated Go for wear resistance based on the 14-day weight loss results. The wear rate was not greater than the maximum acceptable theshold rate of two times that of cupro-nickel 5-cent (see graph above). The wear rate of NPS 5-cent was 24% that of cupro-nickel 5-cent.

Overall Rating: Go

NPS Pilot Material (Quarter-Dollar)

WEAR AND DURABILITY TESTING (May 22 - June 5, 2014)

Performed by: Uvon Tolbert



Average Weight Loss (per piece): NPS 25-cent = 7.5 miligrams
Cupro-nickel clad = 27.2 miligrams

Durability (Edge Deformation): Ending NPS 25-cent Edge Thickness = 0.0685"
Ending Cupro-nickel Edge Thickness = 0.0740"
Deformation = 0.0685 - 0.0740 = - 0.0055"

Durability Rating: NPS 25-cent rated Go for durability because edge deformation difference between it and cupro-nickel clad 25-cent coin from the same wear chamber did not exceed the maximum allowable of 0.010". In fact, NPS 25-cent demonstrated less deformation than baseline cupro-nickel clad.

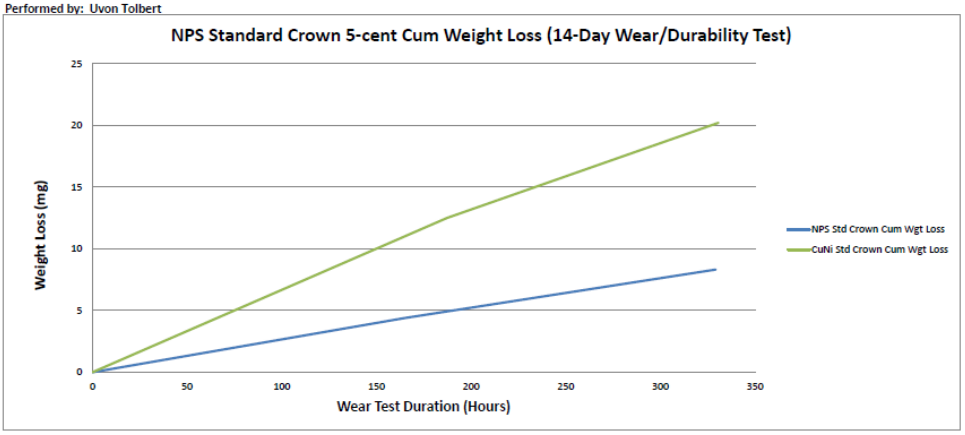
Wear Rating: NPS 25-cent is rated Go for wear resistance based on the 14-day weight loss results. The wear rate was not greater than the maximum acceptable theshold rate of two times that of cupro-nickel clad 25-cent (see graph above). The wear rate of NPS 25-cent was 28% that of cupro-nickel clad 25-cent.

Overall Rating: Go

NPS Pre-production (Five-Cent)

WEAR AND DURABILITY TESTING (Pre-production: June 25 to July 9, 2014)

Performed by: Uvon Tolbert



Average Weight Loss (per piece): NPS 5-cent = 8.3 miligrams
Cupro-nickel = 20.2 miligrams

Durability (Edge Deformation): Ending NPS 5-cent Edge Thickness = 0.0768"
Ending Cupro-nickel Edge Thickness = 0.0820"
Deformation = 0.0780 - 0.0820 = - **0.0052"**

Durability Rating: 5-cent NPS 5-cent rated Go for durability because edge deformation difference between it and cupro-nickel 5-cent coin from the same wear chamber did not exceed the maximum allowable of 0.010". In fact, NPS 5-cent demonstrated less deformation than baseline cupro-nickel.

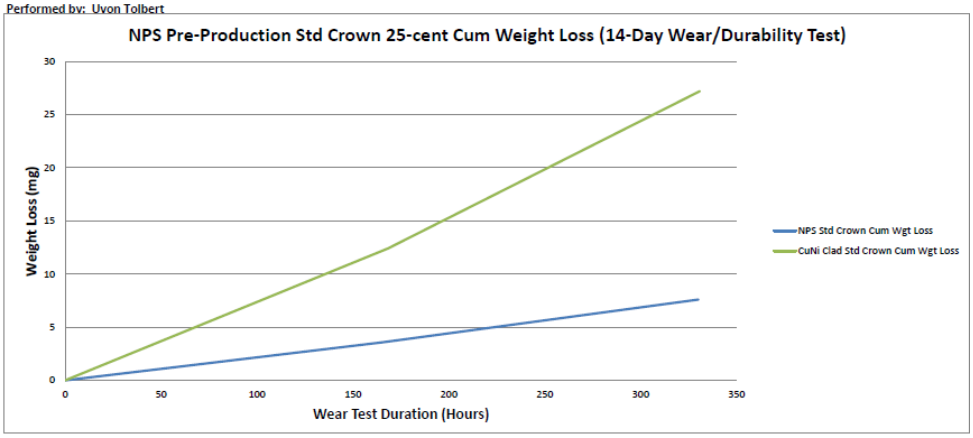
Wear Rating: 5-cent NPS 5-cent is rated Go for wear resistance based on the 14-day weight loss results. The wear rate was not greater than the maximum acceptable theshold rate of two times that of cupro-nickel 5-cent (see graph above). The wear rate of NPS 5-cent was 41% that of cupro-nickel 5-cent.

Overall Rating: Go

NPS Pre-production (Quarter-Dollar)

WEAR AND DURABILITY TESTING (July 16 - July 30, 2014)

Performed by: Uvon Tolbert



Average Weight Loss (per piece): NPS 25 cent = 7.6 miligrams
Current 25 cent = 27.2 miligrams

Durability (Edge Deformation): Ending NPS 25-cent Edge Thickness = 0.0735"
Ending Current 25-cent Edge Thickness = 0.0730"
Deformation = 0.0735 - 0.0730 = **0.0005"**

Durability Rating: NPS 25-cent rated Go for durability because edge deformation difference between it and the current 25-cent coin from the same wear chamber did not exceed the maximum allowable 0.010".

Wear Rating: NPS 25-cent is rated Go for wear resistance based on the 14-day weight loss results. The wear rate was not greater than the maximum acceptable theshold rate of two times that of the current 25-cent (see graph above). The wear rate of NPS 25 cent was 30% that of the current 25 cent.

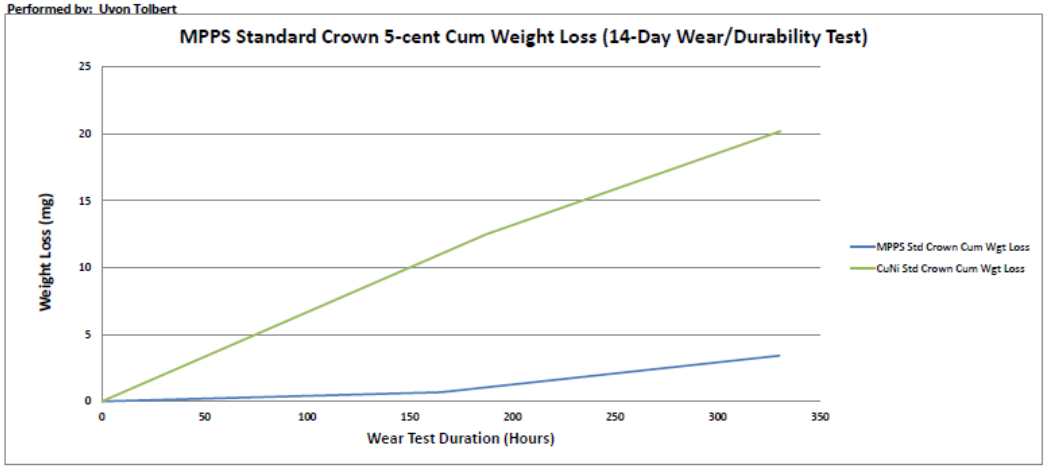
Overall Rating: Go

10.4.2.MPPS

MPPS (Five-Cent) (Pre-Production)

WEAR AND DURABILITY TESTING (Apr 23 - May 21, 2014)

Performed by: Uyon Tolbert



Average Weight Loss (per piece): MPPS 5-cent = 3.4 miligrams
Cupro-nickel = 19 miligrams

Durability (Edge Deformation): Ending MPPS 5-cent Edge Thickness = 0.0795"
Ending Cupro-nickel Edge Thickness = 0.0820"
Deformation = 0.0820 - 0.0810 = - 0.0025"

Durability Rating: 5-cent MPPS 5-cent rated Go for durability because edge deformation difference between it and cupro-nickel 5-cent coin from the same wear chamber did not exceed the maximum allowable of 0.010". In fact, MPPS 5-cent demonstrated less deformation than baseline cupro-nickel.

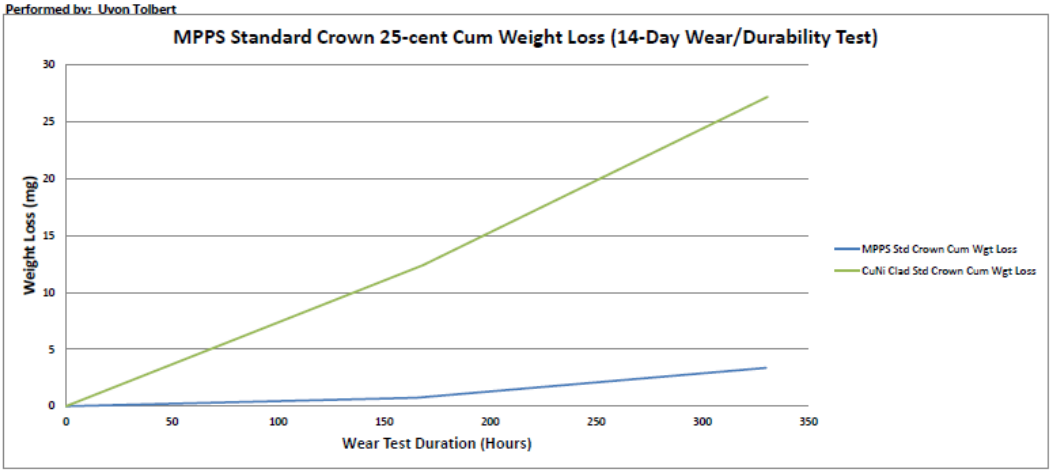
Wear Rating: 5-cent MPPS 5-cent is rated Go for wear resistance based on the 14-day weight loss results. The wear rate was not greater than the maximum acceptable theshold rate of two times that of cupro-nickel 5-cent (see graph above). The wear rate of MPPS 5-cent was 18% that of cupro-nickel 5-cent.

Overall Rating: Go

MPPS (Quarter-Dollar) (Pre-Production)

WEAR AND DURABILITY TESTING (Apr 23 - May 21, 2014)

Performed by: Uvon Tolbert



Average Weight Loss (per piece): MPPS 25-cent = 3.4 miligrams
Cupro-nickel clad = 27.2 miligrams

Durability (Edge Deformation): Ending MPPS 25-cent Edge Thickness = 0.0690"
Ending Cupro-nickel Edge Thickness = 0.0740"
Deformation = 0.0690 - 0.0740 = - 0.0050"

Durability Rating: MPPS 25-cent rated Go for durability because edge deformation difference between it and cupro-nickel clad 25-cent coin from the same wear chamber did not exceed the maximum allowable of 0.010". In fact, MPPS 25-cent demonstrated less deformation than baseline cupro-nickel clad.

Wear Rating: MPPS 25-cent is rated Go for wear resistance based on the 14-day weight loss results. The wear rate was not greater than the maximum acceptable theshold rate of two times that of cupro-nickel clad 25-cent (see graph above). The wear rate of MPPS 25-cent was 16% that of cupro-nickel clad 25-cent.

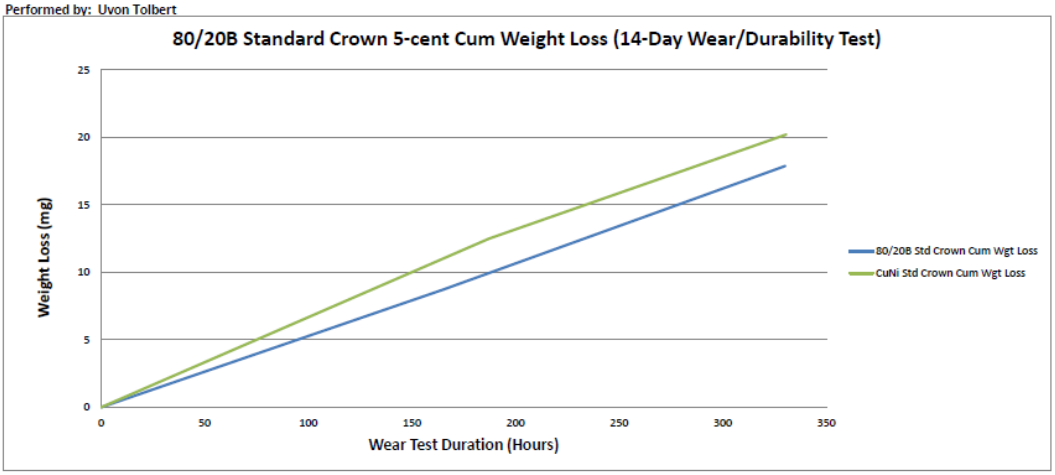
Overall Rating: Go

10.4.3.80/20B

Initial 80/20B Five-Cent (Pre-Production)

WEAR AND DURABILITY TESTING (Apr 23 - May 7, 2014)

Performed by: Uvon Tolbert



Average Weight Loss (per piece): 80/20B 5 cent = 17.9 miligrams
Current 5 cent = 21.0 miligrams

Durability (Edge Deformation): Ending 80/20B Edge Thickness = 0.0827"
Ending Current 5-cent Edge Thickness = 0.0820"
Deformation = 0.0827 - 0.0820 = **0.0007"**

Durability Rating: 5-cent 80/20B rated Go for durability because edge deformation difference between it and the current 5-cent coin from the same wear chamber did not exceed the maximum allowable of 0.010".

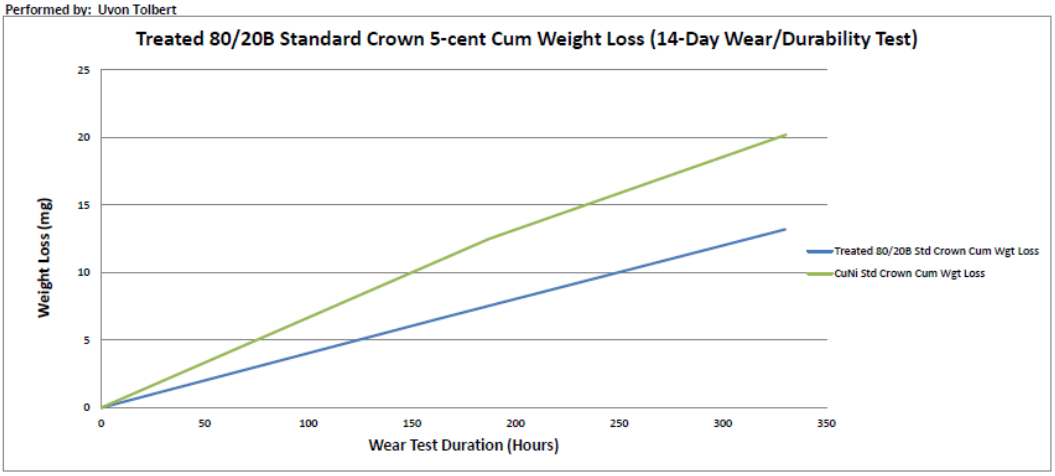
Wear Rating: 5-cent 80/20B is rated Go for wear resistance based on the 14-day weight loss results. The wear rate was not greater than the maximum acceptable theshold rate of two times that of the current 5 cent (see graph above). The wear rates of 80/20B was less than that of current 5 cent.

Overall Rating: Go

Treated 80/20B Five-Cent (Pre-Production)

WEAR AND DURABILITY TESTING (Jul 23 - Aug 6, 2014)

Performed by: Uvon Tolbert



Average Weight Loss (per piece): Treated 80/20B 5-cent = 13.2 miligrams
Cupro-nickel = 20.2 miligrams

Durability (Edge Deformation): Ending 80/20B Edge Thickness = 0.0790"
Ending Cupro-nickel Edge Thickness = 0.0812"
Deformation = 0.0790 - 0.0812 = **-0.0022"**

Durability Rating: 5-cent 80/20B rated Go for durability because edge deformation difference between it and cupro-nickel 5-cent coin from the same wear chamber did not exceed the maximum allowable of 0.010". In fact, 5-cent 80/20B deformed less than cupro-nickel tested under the same conditions.

Wear Rating: 5-cent 80/20B is rated Go for wear resistance based on the 14-day weight loss results. The wear rate was not greater than the maximum acceptable theshold rate of two times that of cupro-nickel 5-cent (see graph above). The wear rates of 80/20B was 65% that of cupro-nickel 5-cent.

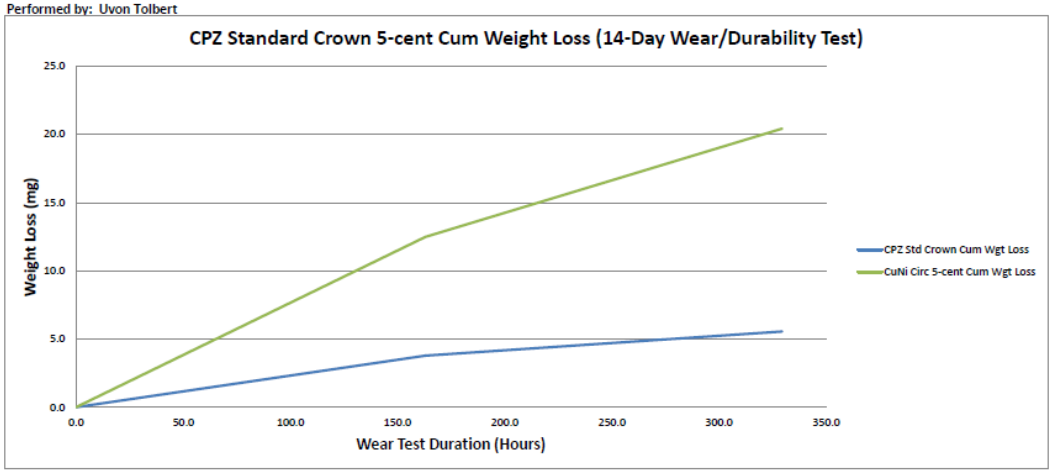
Overall Rating: Go

10.4.4.CPZ

CPZ Five-Cent (Pre-Production)

WEAR AND DURABILITY TESTING (Apr 9 to Apr 23, 2014)

Performed by: Uvon Tolbert



Average Weight Loss (per piece): CPZ = 5.6 miligrams
Cupro-nickel = 20.1 miligrams

Durability (Edge Deformation): Ending CPZ Edge Thickness = 0.0845"
Ending Cupro-nickel Edge Thickness = 0.070"
Deformation = 0.0845 - 0.070 = **0.0145"**

Durability Rating: 5-cent CPZ is rated No Go for durability because edge deformation difference between it and cupro-nickel 5-cent coin from the same wear chamber exceeded the maximum allowable of 0.010".

Wear Rating: 5-cent CPZ is rated **Go** for wear resistance based on the first week's weight loss results, which suggests a wear rate comparable to cupro-nickel 5-cent (see graph above). However, increasing edge thickness as wear testing continued (edge deformation) served to reduce sliding wear to obverse/reverse designs (see graph above), reducing weight loss.

Overall Rating: No Go

10.5. Steam Test Results – Pre-Production

10.5.1.Nickel-Plated Steel

NPS Pilot Material (Five-Cent)

RM NPS 5 Cent Blanks Pre-Production Tests Color Change Before and After Steam Test

Test Date: 05/20/14

Operator: Tony Ying

The average measured values of 40 RM NPS 5-cent blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the tanks. The standard deviations of the measurement are also listed in the same table.

Table 1: The average and deviation of RM NPS 5-cent blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	82.24	0.69	6.97	0.58	0.03	0.14
After steam test	79.08	1.01	9.96	0.73	0.07	0.48

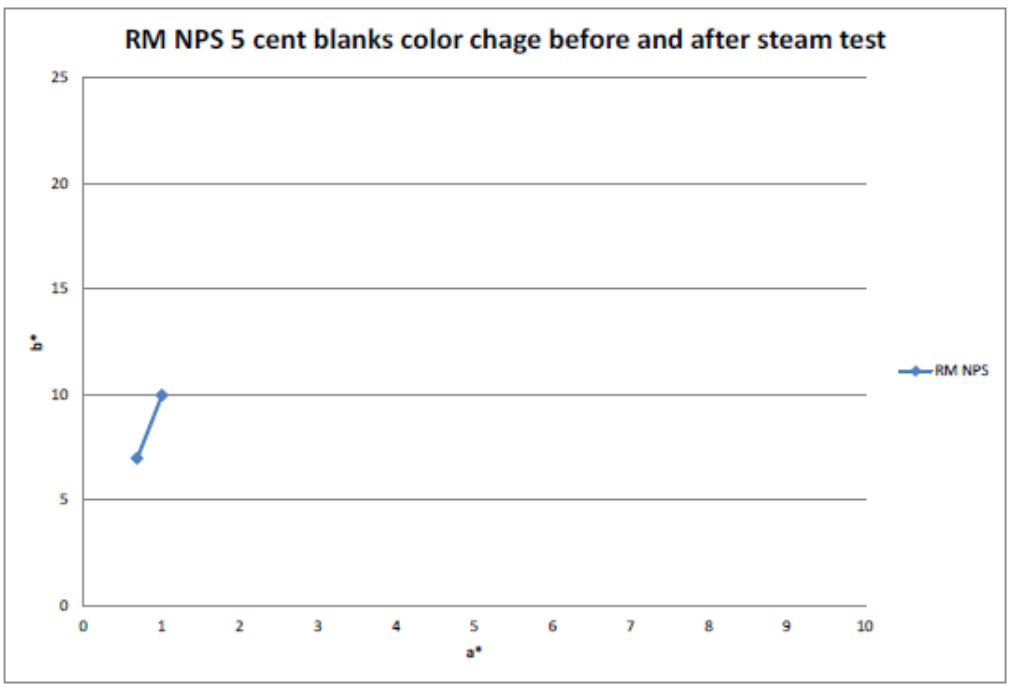


Figure 1: The color change of RM NPS 5-cent blanks.

NPS Pilot Material (Quarter-Dollar)

RM NPS 25 Cent Blanks Pre-Production Pilot Tests Color Change Before and After Steam Test

Test Date: 06/05/14

Operator: Tony Ying

The average measured values of 20 RM Pilot NPS 25-cent blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the tanks. The standard deviations of the measurement are also listed in the same table.

Table 1: The average and deviation of RM NPS Pilot 25-cent blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	81.57	0.72	7.19	0.68	0.03	0.21
After steam test	78.23	1.09	10.10	1.31	0.16	2.23

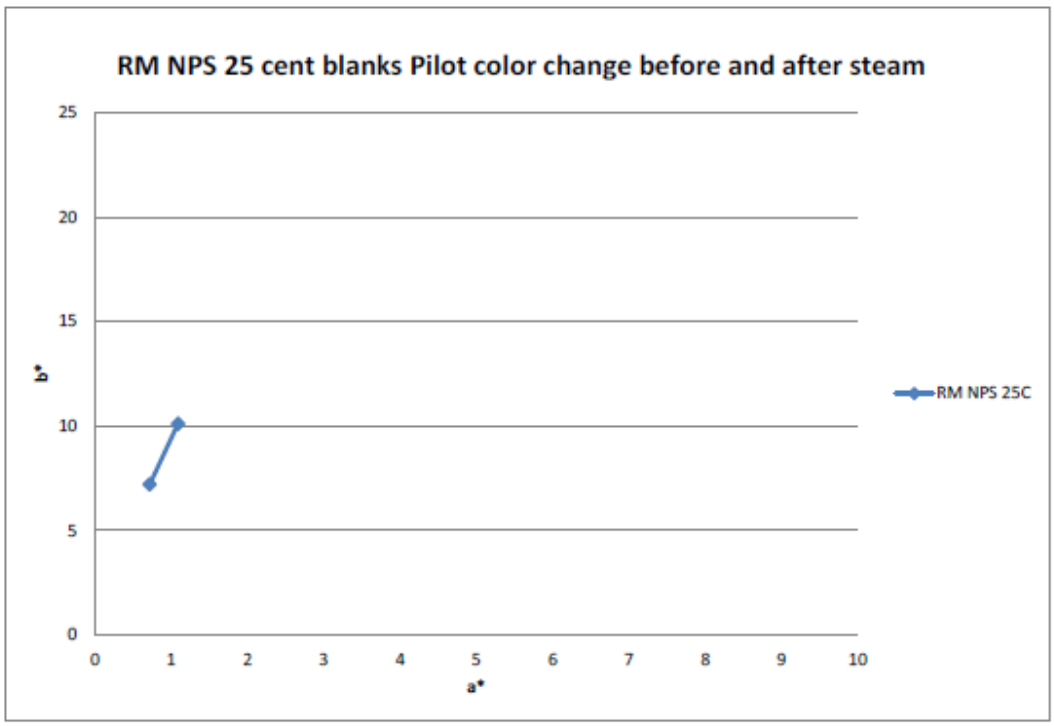


Figure 1: The color change of RM NPS Pilot 25-cent blanks.

NPS Pre-production (Five-Cent)

RM NPS 5 Cent Blanks Pre-Production Tests Color Change Before and After Steam Test

Test Date: 06/19/14

Operator: Uvon Tolbert

The average measured values of 20 RM NPS 5-cent blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the tanks. The standard deviations of the measurement are also listed in the same table.

Table 1: The average and deviation of RM NPS 5-cent blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	81.46	0.74	7.20	1.13	0.05	0.29
After steam test	78.86	1.09	10.45	2.47	0.12	0.78

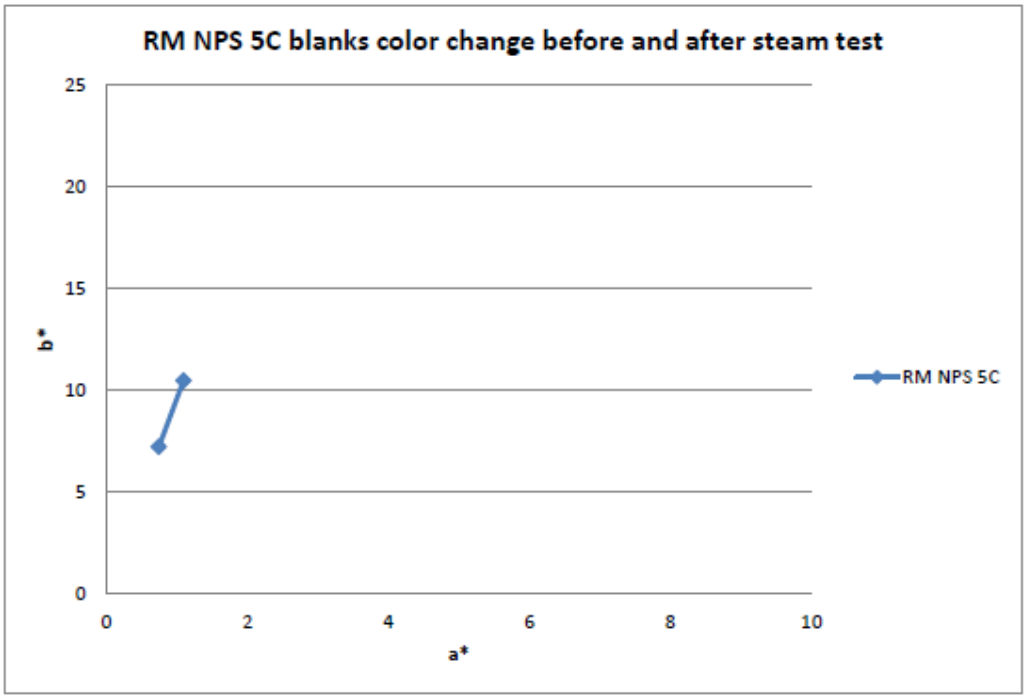


Figure 1: The color change of RM NPS 5-cent blanks.

NPS Pre-production (Quarter-Dollar)

RM NPS 25 Cent Blanks Pre-Production Tests Color Change Before and After Steam Test

Test Date: 07/23/14

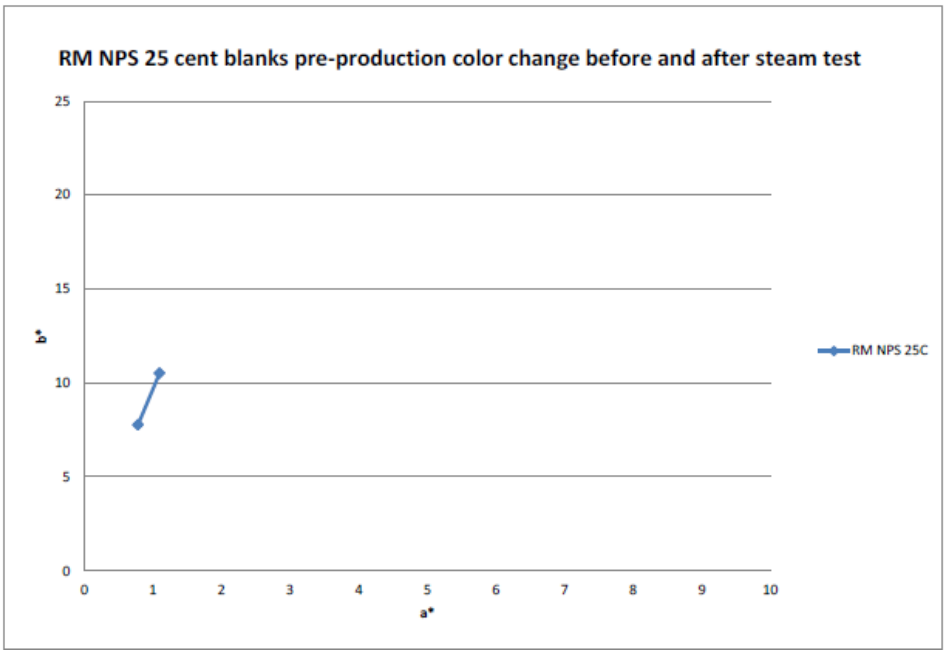
Operator: Tony Ying

The average measured values of 20 RM NPS 25-cent blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the tanks. The standard deviations of the measurement are also listed in the same table.

Table 1: The average and deviation of RM NPS cent blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	80.87	0.79	7.76	1.06	0.07	0.40
After steam test	78.22	1.10	10.51	1.35	0.15	0.95



10.5.2.MPPS

MPPS (Five-Cent) (Pre-production)

RCM MPPS 5 Cent Blanks Pre-Production Tests Color Change Before and After Steam Test

Test Date: 04/28/14

Operator: Uvon Tolbert

The average measured values of 20 RCM MPPS 5-cent blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the tanks. The standard deviations of the measurement are also listed in the same table.

Table 1: The average and deviation of RCM MPPS 5-cent blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	85.56	1.22	10.22	0.96	0.12	0.42
After steam test	74.90	2.11	11.42	1.03	2.22	0.30

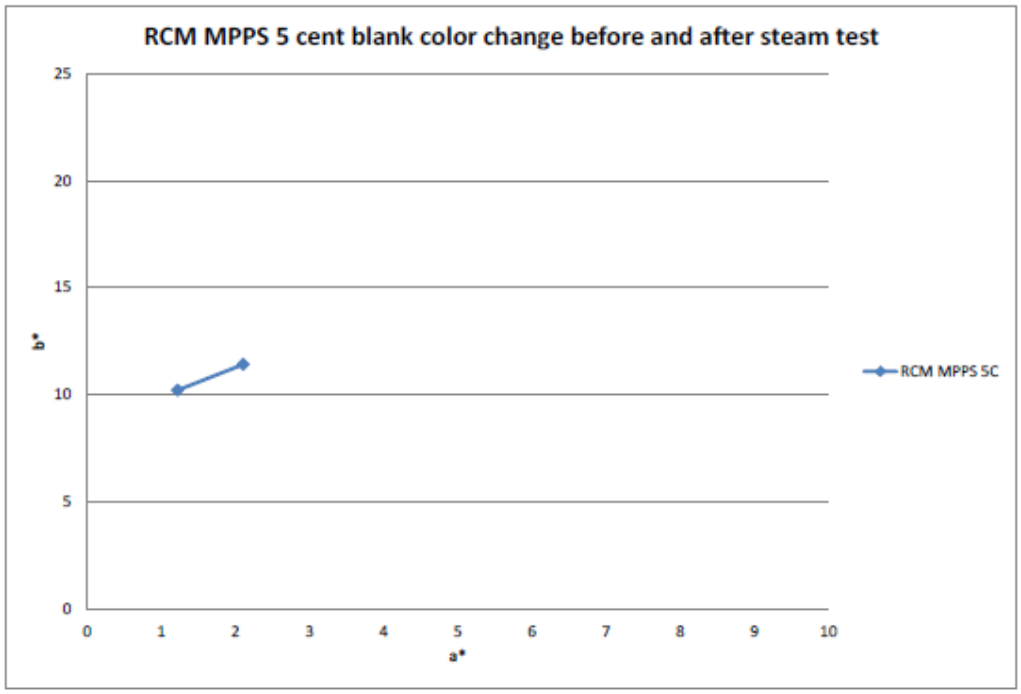


Figure 1: The color change of RCM MPPS 5-cent blanks.

MPPS (Quarter-Dollar) (Pre-production)

RCM MPPS 25 Cent Blanks Pre-Production Tests Color Change Before and After Steam Test

Test Date: 05/01/14

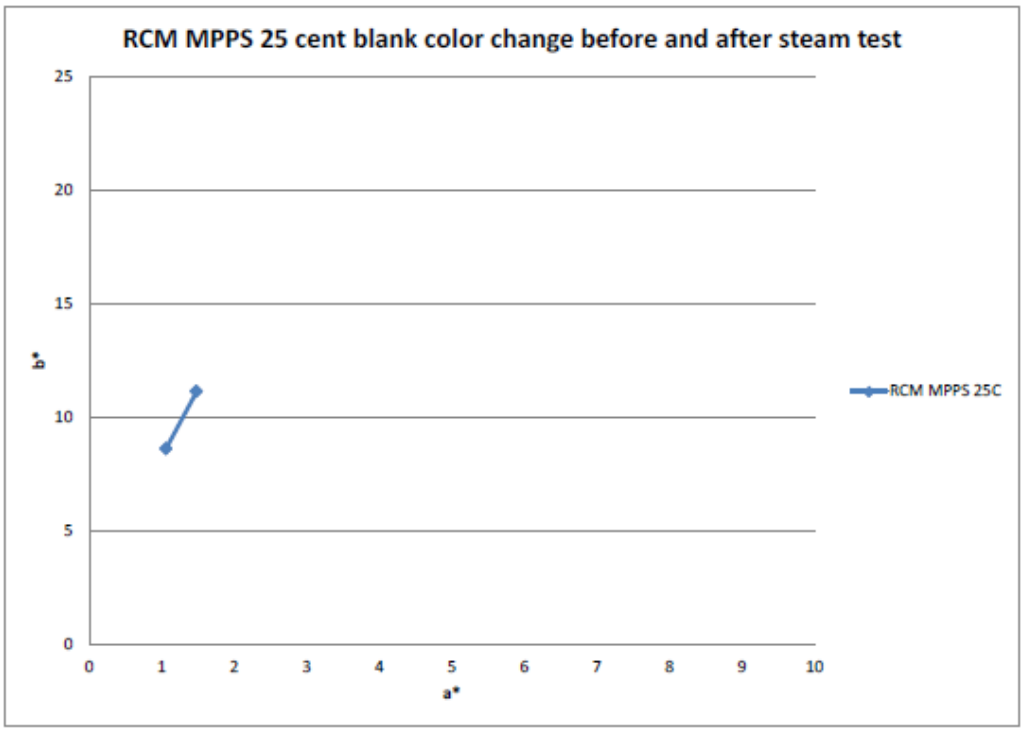
Operator: Uvon Tolbert

The average measured values of 20 RCM MPPS 25-cent blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the tanks. The standard deviations of the measurement are also listed in the same table.

Table 1: The average and deviation of RCM MPPS 25-cent blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	77.93	1.06	8.60	1.11	0.11	0.40
After steam test	75.00	1.48	11.13	1.60	0.15	0.67



10.5.3.80/20B

80/20B Five-Cent (Pre-Production)

80/20B CuNi 5 Cent Blanks Pre-Production Tests Color Change Before and After Steam Test

Test Date: 05/20/14

Operator: Tony Ying

The average measured values of 40 80/20B CuNi 5-cent blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the tanks. The standard deviations of the measurement are also listed in the same table.

Table 1: The average and deviation of 80/20B CuNi 5-cent blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	82.23	1.82	8.78	0.63	0.10	0.27
After steam test	75.04	2.64	16.59	1.70	0.33	1.33

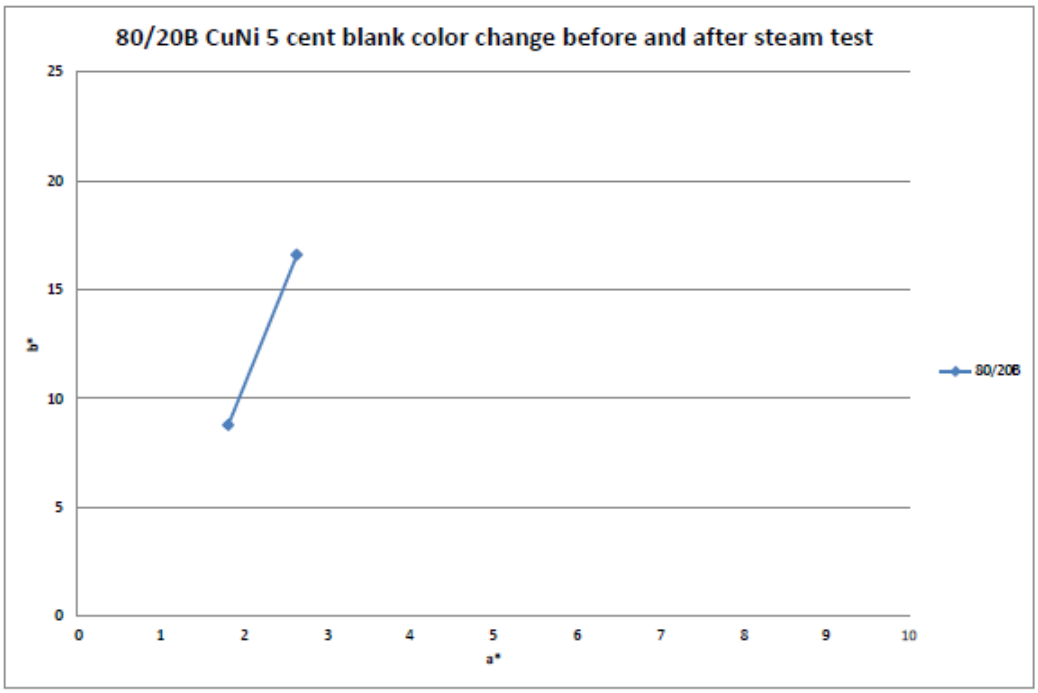


Figure 1: The color change of 80/20B CuNi 5-cent blanks.

Overall Assessment: comparable to the current cupronickel material.

80/20B Five-Cent Lubricated (Pre-Production)

80/20B CuNi 5 Cent Lubricated Blanks Pre-Production Tests Color Change Before and After Steam Test

Test Date: 07/08/14

Operator: Tony Ying

The average measured values of 20 80/20B CuNi 5-cent lubricated blanks before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the tanks. The standard deviations of the measurement are also listed in the same table.

Table 1: The average and deviation of 80/20B CuNi 5-cent lubricated blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	81.88	1.91	8.96	0.37	0.07	0.25
After steam test	71.84	4.01	19.91	3.46	0.90	3.04

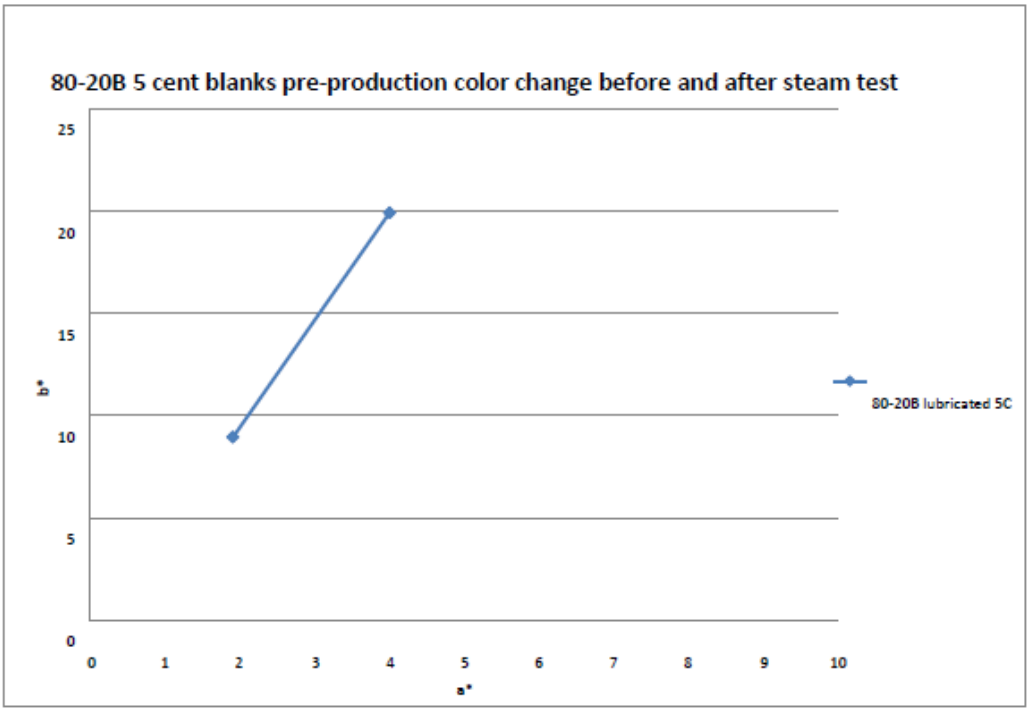


Figure 1: The color change of 80/20B CuNi 5-cent lubricated blanks.

Overall Assessment: Comparable to the current cupronickel material.

10.5.4.CPZ

CPZ Five-Cent (Pre-Production)

CPZ 5 Cent Blanks Pre-Production Tests Color Change Before and After Steam Test

Test Date: 04/01/14

Operator: Tony Ying

The average measured values of 20 CPZ 5 cent blanks for pre-production before and after 2-hour steam test are listed in table 1.

These blanks are randomly collected from the envelope. The standard deviations of the measurement are also listed in the same table.

Table 1: The average and deviation of CPZ blank colors

	L* average	a* average	b* average	L* standard deviation	a* standard deviation	b* standard deviation
Before steam test	80.09	16.90	20.80	1.08	0.69	0.70
After steam test	77.70	17.67	23.08	1.44	0.62	0.65

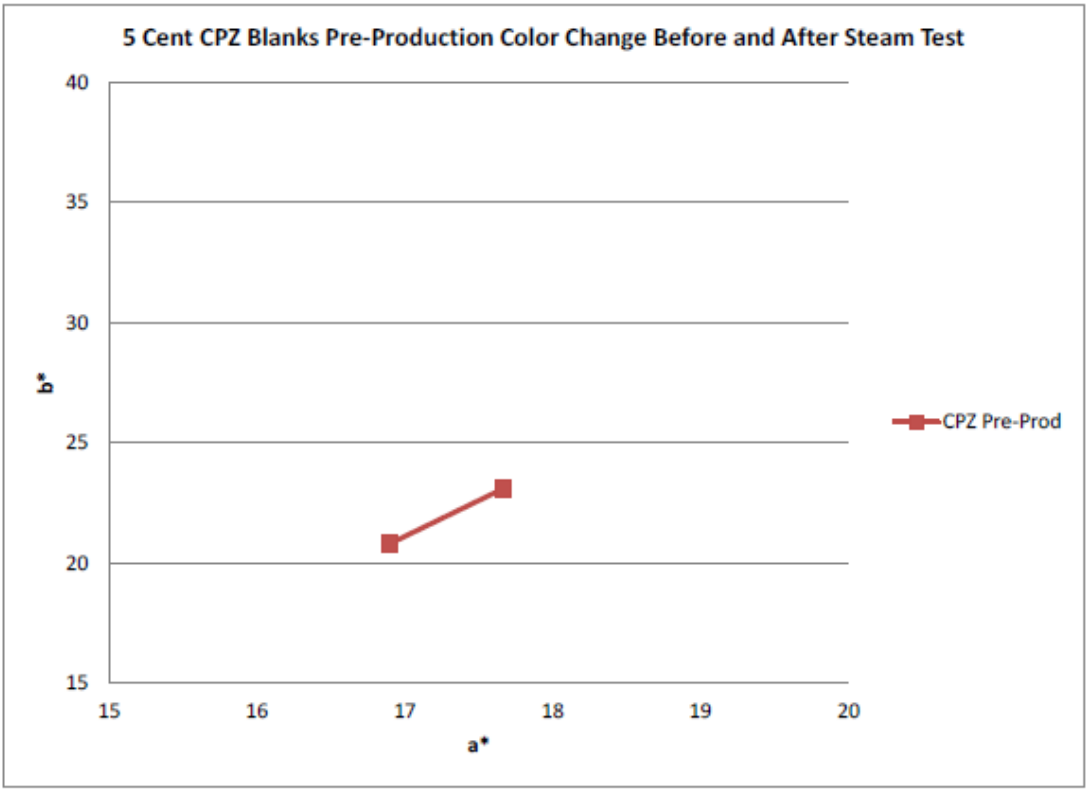
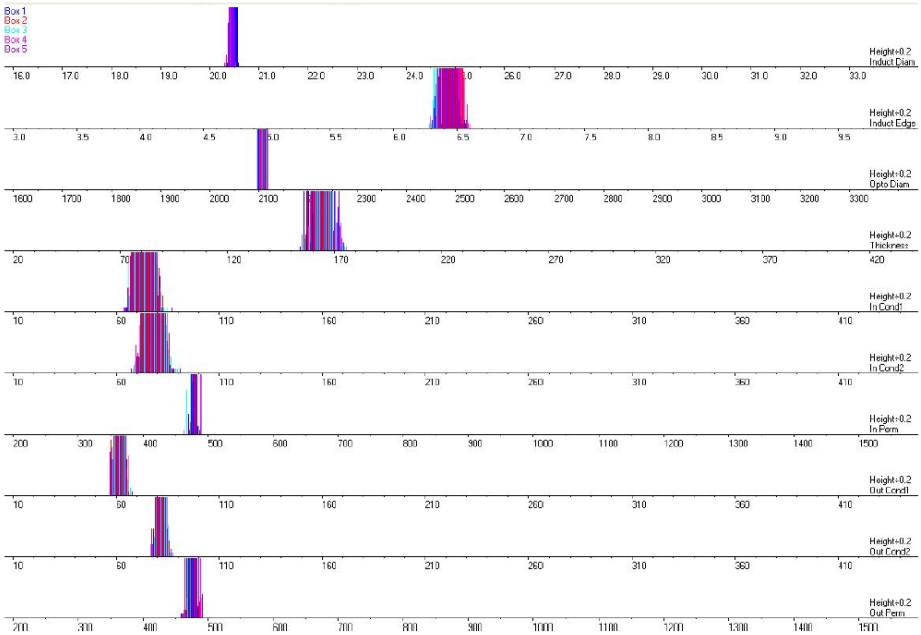


Figure 1: The color change of CPZ blanks.

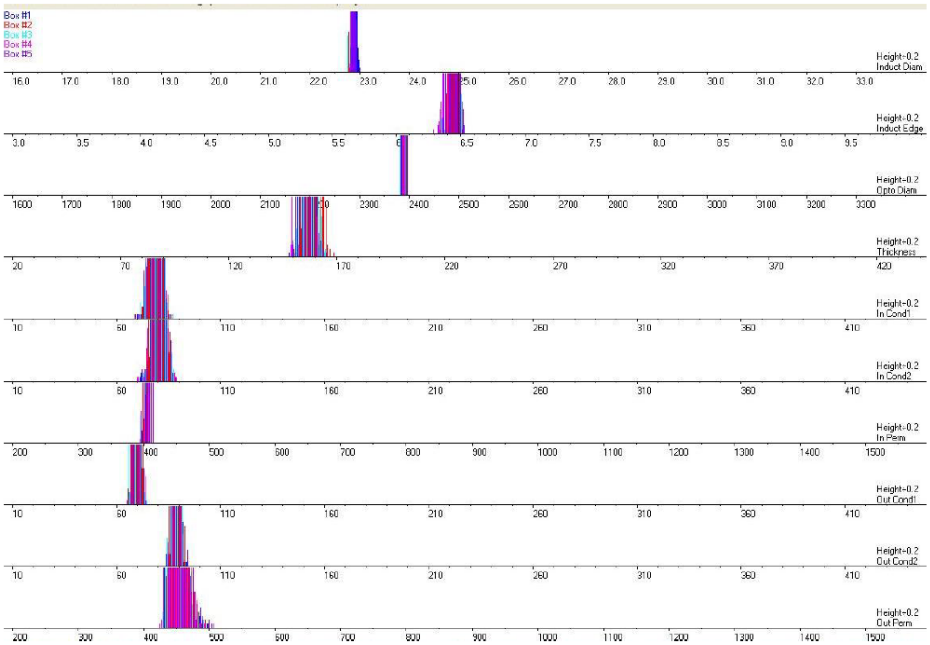
10.6. CSV Test Results – Pre-Production

10.6.1.NPS

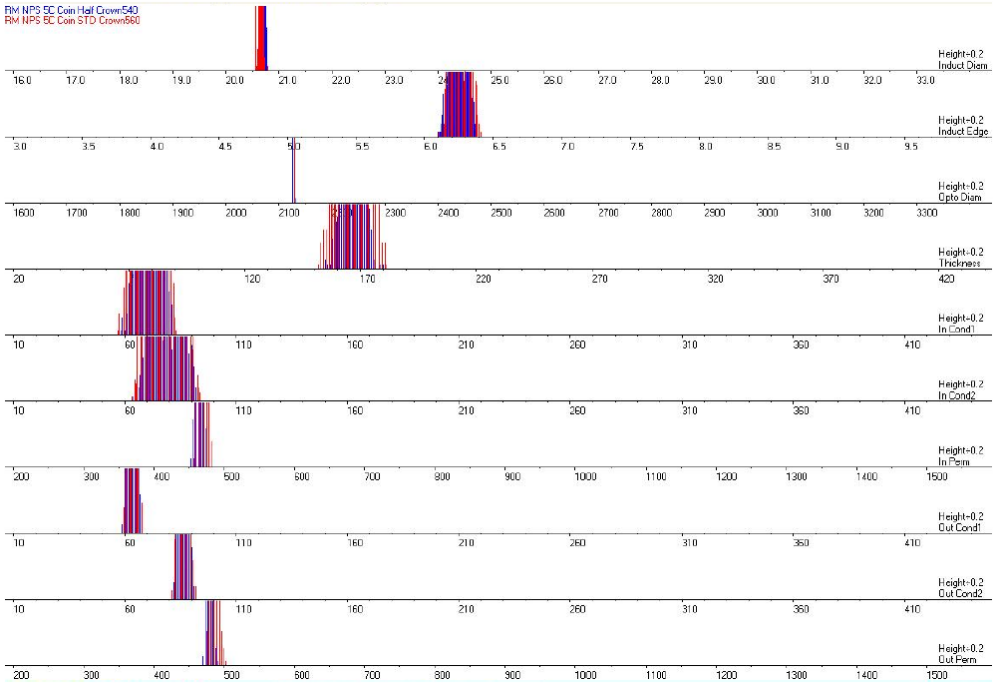
NPS Pilot Material – Planchet (Five-Cent)



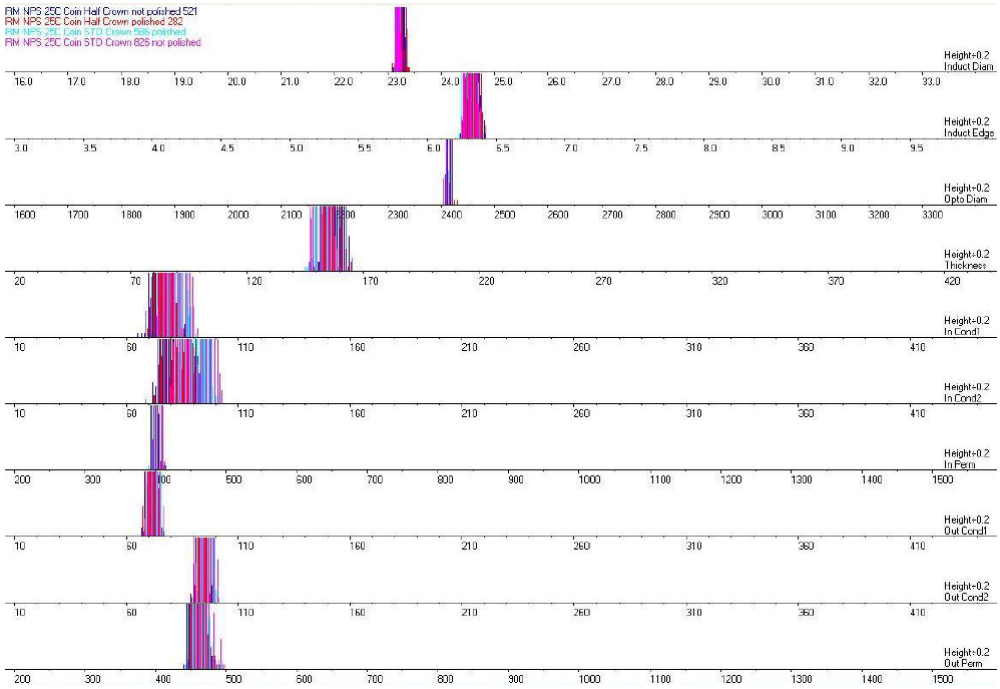
NPS Pilot Material – Planchet (Quarter-Dollar)



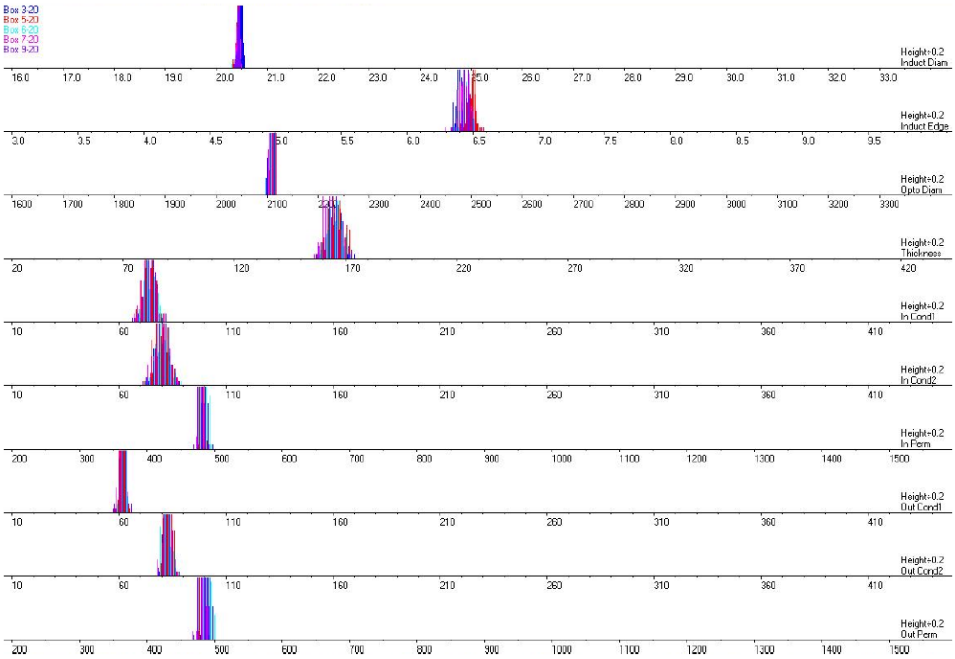
NPS Pilot Material – Coin (Five-Cent)



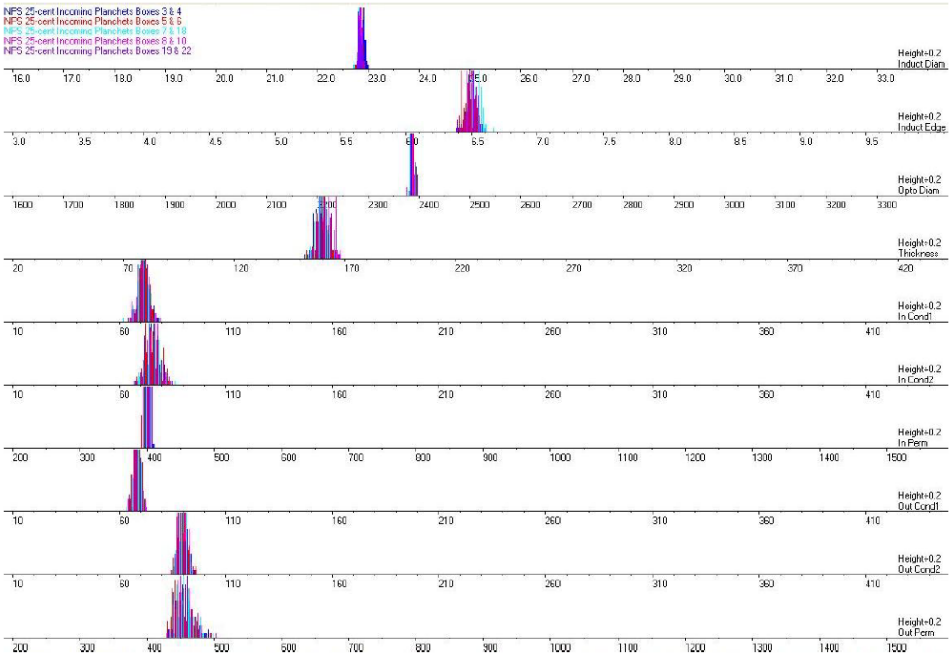
NPS Pilot Material – Coin (Quarter-Dollar)



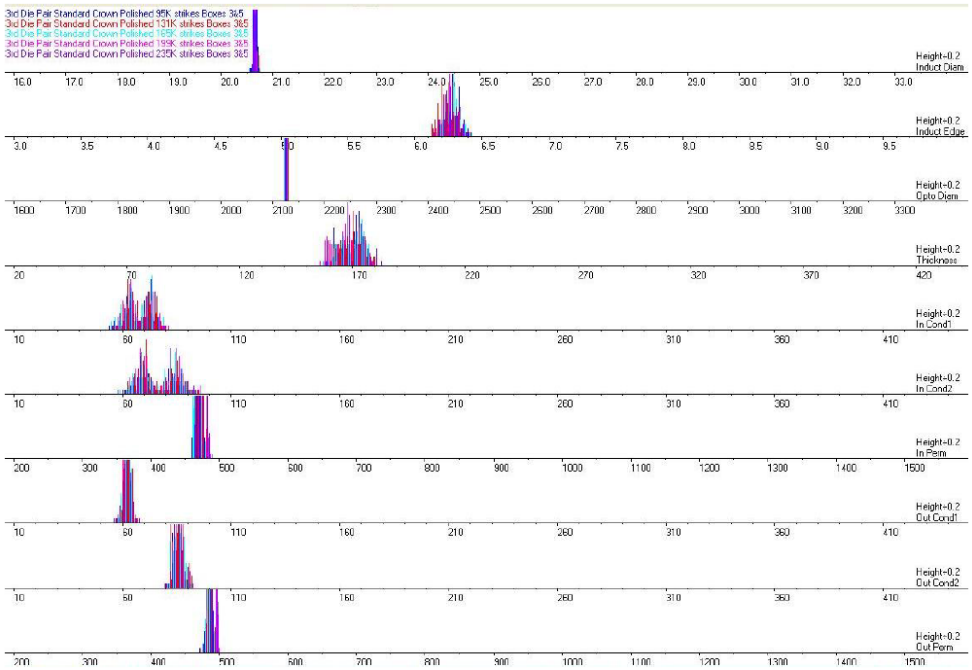
NPS Pre-production – Planchet (Five-Cent)



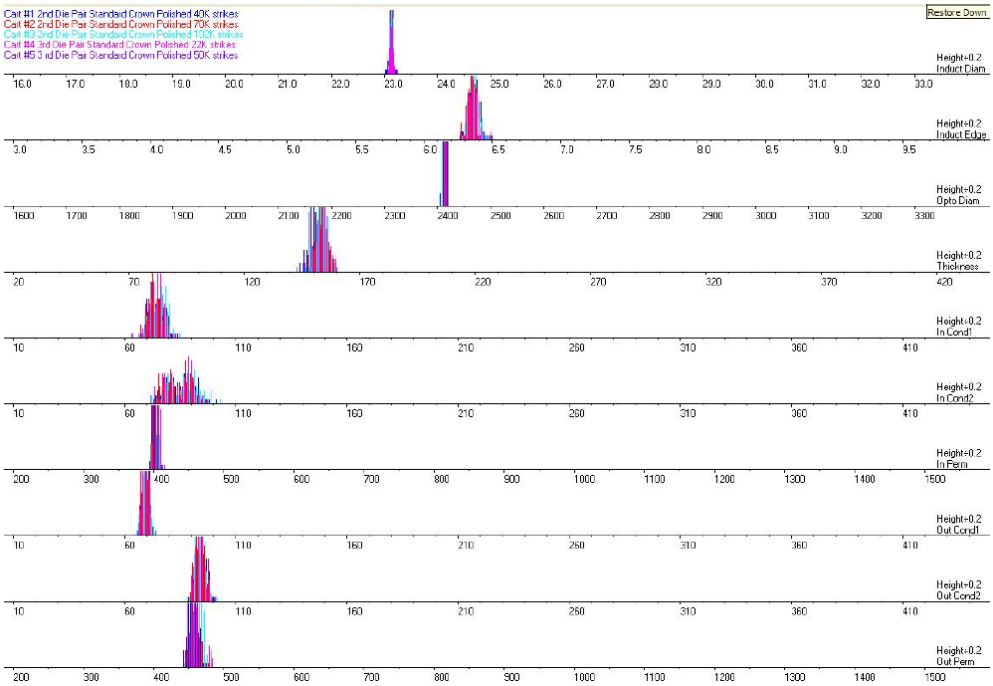
NPS Pre-production – Planchet (Quarter-Dollar)



NPS Pre-production – Coin (Five-Cent)

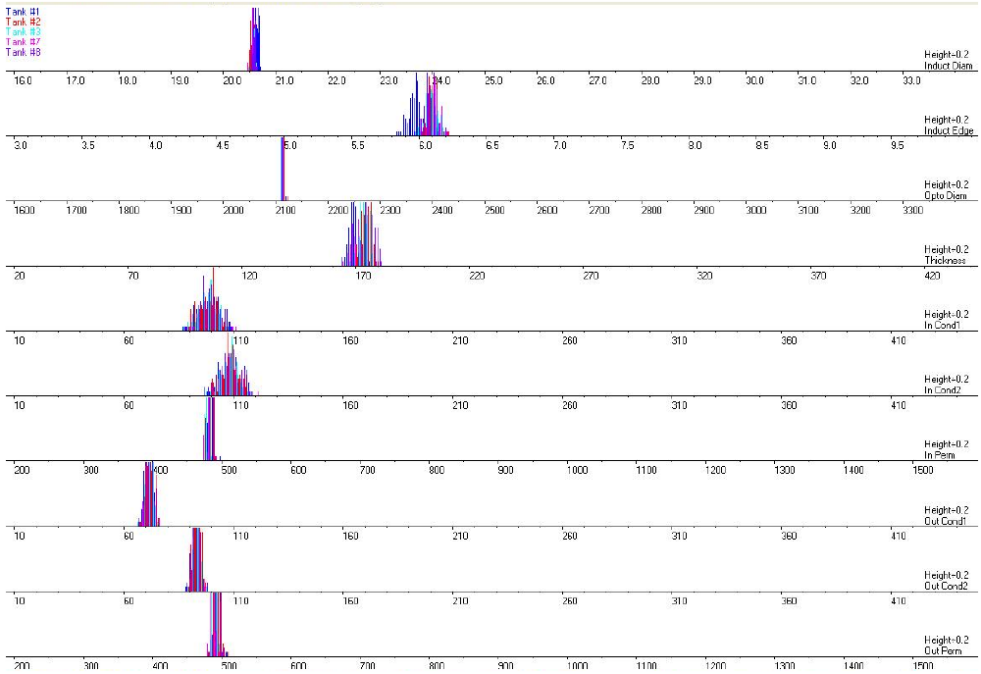


NPS Pre-production – Coin (Quarter-Dollar)

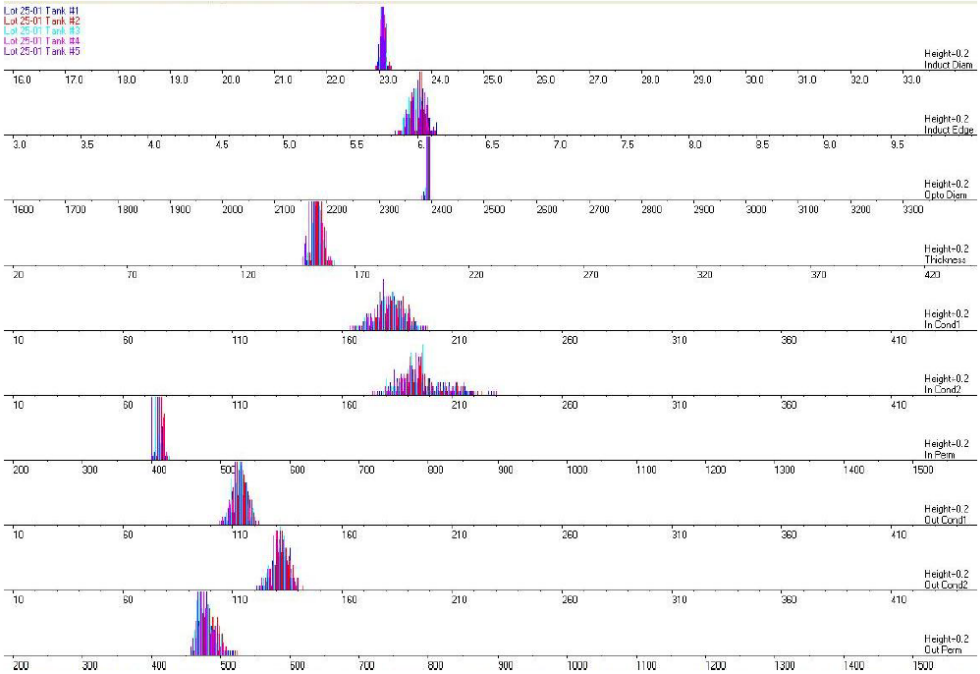


10.6.2.MPPS

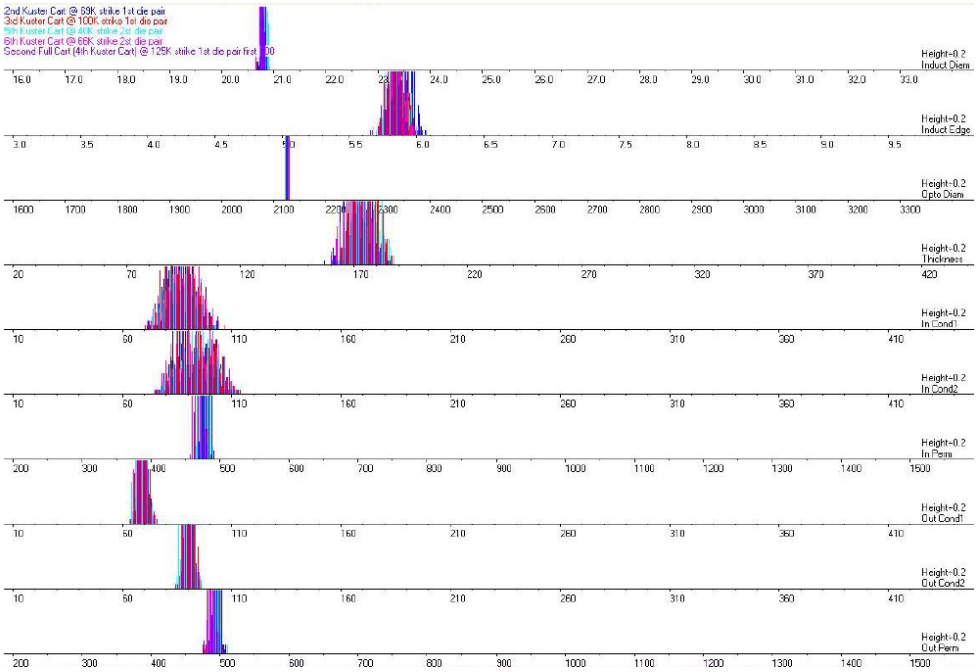
MPPS Pre-production – Planchet (Five-Cent)



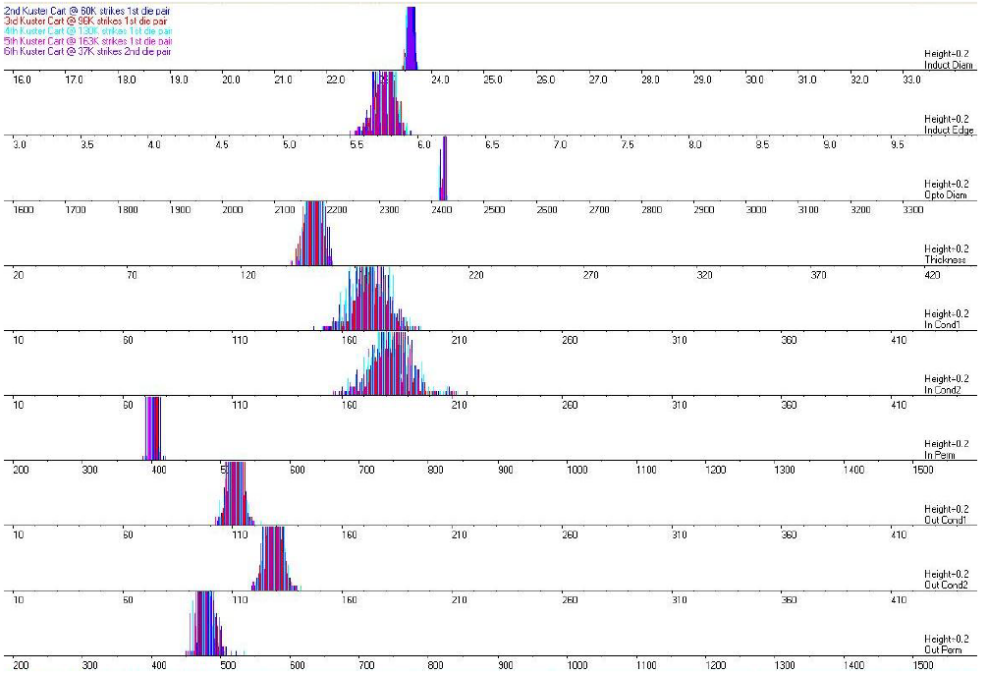
MPPS Pre-production – Planchet (Quarter-Dollar)



MPPS Pre-production – Coin (Five-Cent)

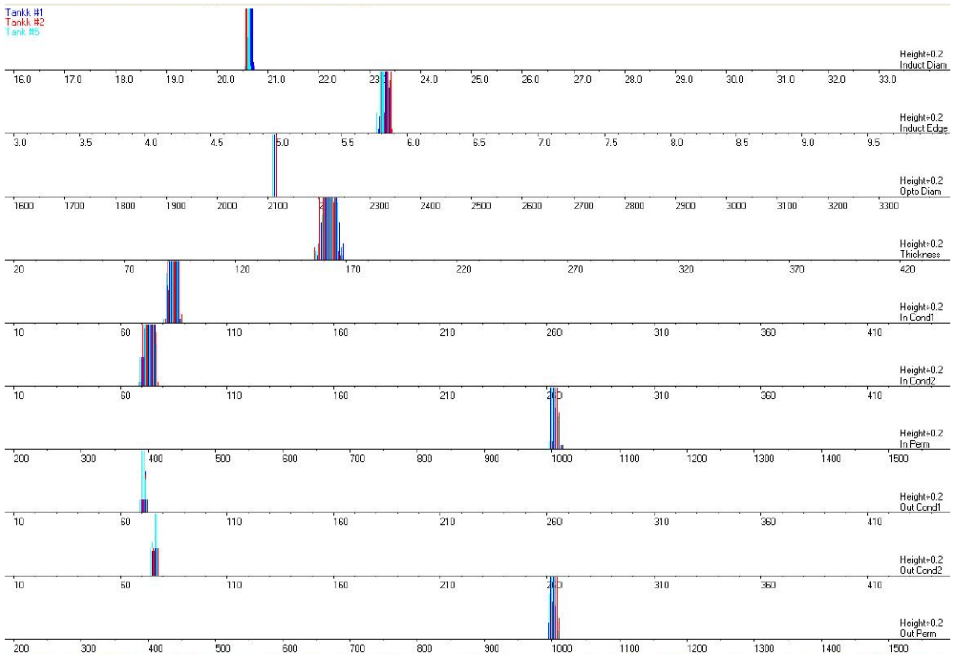


MPPS Pre-production – Coin (Quarter-Dollar)

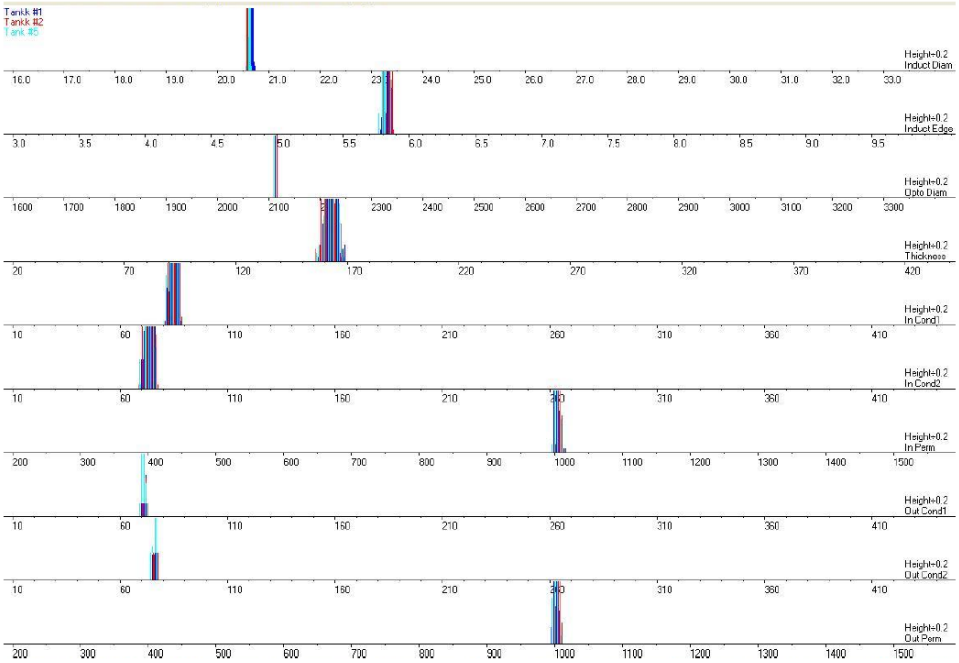


10.6.3.80/20B

80/20B Pre-production – Planchet (Five-Cent)

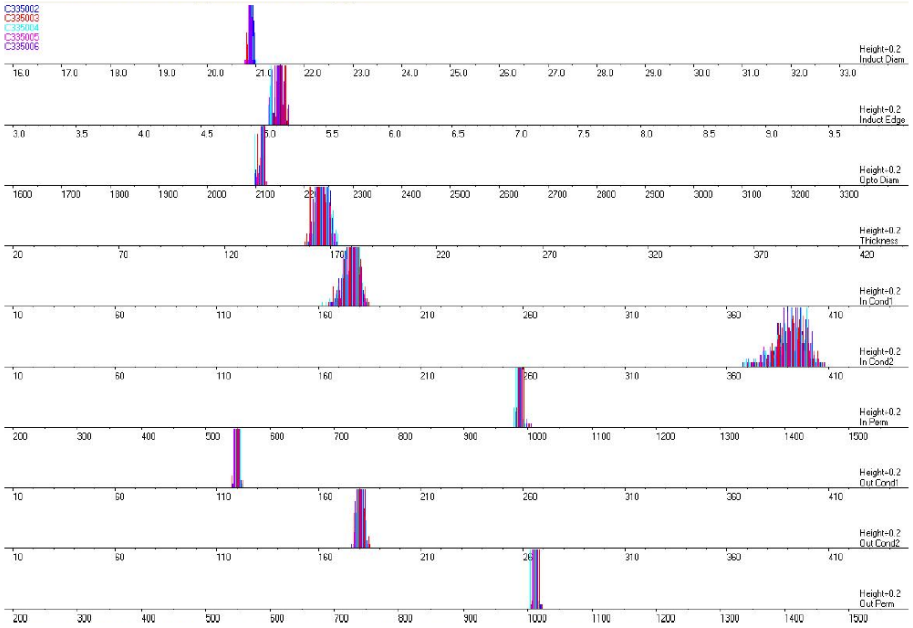


80/20B Pre-production – Coin (Five-Cent)

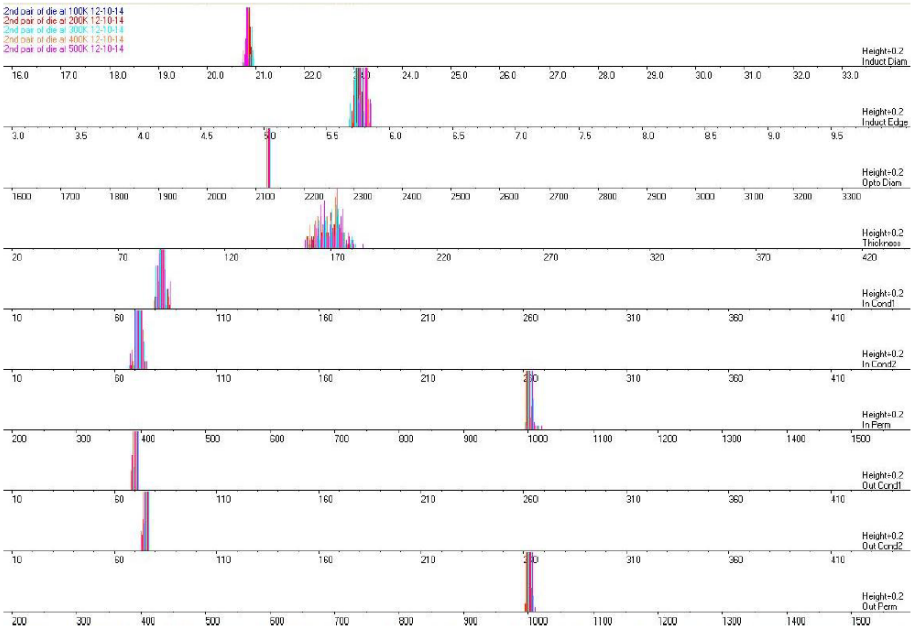


10.6.4.CPZ

CPZ Pre-production – Planchet (Five-Cent)



CPZ Pre-production – Coin (Five-Cent)



10.7. CSV Comparison—Plated Steel v. Current Material

MATERIAL (Five-Cent))	CSV ELECTROMAGNETIC SIGNATURES AVERAGE / RANGE WIDTH						COMMENTS
	Inner Conductivity 1	Inner Conductivity 2	Inner Permeability	Outer Conductivity 1	Outer Conductivity 2	Outer Permeability	
Current Cu-Ni	**82 / 9.7**	**71 / 9.8**	**1004 / 14.5**	**70 / 3.4**	**75 / 3.4**	**1003 / 13.9**	**Current**
80/20	84 / 9.6	73 / 9.4	1007 / 12.2	71 / 2.9	76 / 2.7	1007 / 10.1	Seamless
MPPS	91 / 35.8	99 / 44.9	485 / 24.4	70 / 9.9	91 / 10.2	501 / 20.9	
NPS	68 / 32.5	76 / 43.5	472 / 27.8	62 / 8.8	85 / 8.6	488 / 20.9	
Stainless (302HQ)	31 / 6.0	11 / 5.5	997 / 12.4	47 / 3.0	56 / 3.0	995 / 11.6	

The first number is the average for that material. The second number is how much variance is seen in that material. The larger the second number, the wider the coin acceptor's "window" of acceptance must open to accept both.

MATERIAL (Quarter-Dollar)	CSV ELECTROMAGNETIC SIGNATURES AVERAGE / RANGE WIDTH						COMMENTS
	Inner Conductivity 1	Inner Conductivity 2	Inner Permeability	Outer Conductivity 1	Outer Conductivity 2	Outer Permeability	
Current Cu-Ni Clad	**68 / 18.9**	**550 / 62.5**	**825 / 21.0**	**115 / 12.9**	**287 / 7.2**	**1006 / 15.5**	**Current**
MPPS	176 / 44.9	189 / 60.7	400 / 17.5	113 / 16.5	131 / 18.1	475 / 37.2	Not Feasible
NPS	82 / 23.3	90 / 36.6	398 / 16.5	72 / 9.1	95 / 11.4	457 / 49.4	Not Feasible

1. EMS ranges that overlap those of the current are highlighted in yellow.
2. Plated-steel EMS ranges are wider than those of the current, necessitating wider acceptance windows and less security.
3. Plated-steel and monolithic EMS ranges tend to overlap at multiple frequencies, diminishing the enhanced security of dual-frequency coin validation.
4. Cupronickel clad construction offers high security, as evidence by the low incidence of EMS overlap with MPPS and NPS.

11. Acronym List

°C	degrees Celsius
µm	micrometer, micron, 1 millionth of a meter
COGS	cost of goods sold
CPZ	copper-plated zinc
CSV	coin sorter/validator
DOE	Department of Energy
EMS	electromagnetic signature
EVA	European Vending Association
FRB	Federal Reserve Bank
IA	interagency agreement
IACS	International Annealed Copper Standard
IPR	independent peer review
IV&V	independent verification and validation
MPPS	multi-ply-plated steel
NIST	National Institute of Standards and Technology
NPS	nickel-plated steel
PL	public law
PVD	physical vapor deposition
R&D	research and development
RCM	Royal Canadian Mint
RM	The Royal Mint (UK)
SOP	standard operating procedures
TPCPZ	tin-plated, copper-plated zinc
USPS	United States Postal Service

Table 2-12. Estimated Cost Breakdown – Current and Alternative Metals

5¢	Annualized Volume	Weight (grams)	Metal Cost	Metal + Supplier Fab + USM Direct Production	USM O/H+ G&A + Distribution	Total Unit Cost	% Savings	Savings Compared to YTD FY-14 5¢ through March 2014 984 M Coins	Notes
FY13 5¢ 1,123 M Coins		5.00	$0.0530	$ 0.0662	$ 0.0279	$ 0.0941		$ -	a
FY14 5¢ (75-25) -->3/31/14 492M coins	984 M	5.00	$0.0421	$ 0.0539	$ 0.0248	$ 0.0787	-16.4%	$ 15,189,203	b
80-20Cu-Ni Solid		4.96	$0.0388	$ 0.0507	$ 0.0248	$ 0.0754	-4.1%	$ 3,211,103	e
Multi-Ply plated steel (p)		4.37	$0.0281	$ 0.0302	$ 0.0248	$ 0.0550	-30.1%	$ 23,335,468	q
3XX Stainless steel (s)		4.46	$0.0211	$ 0.0335	$ 0.0248	$ 0.0583	-25.9%	$ 20,097,771	e
Nickel plated steel (p)		4.40	$0.0342	$ 0.0363	$ 0.0248	$ 0.0611	-22.3%	$ 17,310,451	q
CPZ (p) 8 µm		4.06	$0.0094	$ 0.0191	$ 0.0248	$ 0.0439	-44.2%	$ 34,254,534	q
Tin plated CPZ (p)		4.10	$0.0197	$ 0.0218	$ 0.0248	$ 0.0466	-40.8%	$ 31,614,856	q
10¢	**Annual Volume**	**Weight (grams)**	**Metal Cost**	**Metal + Supplier Fab + USM Direct Production**	**USM O/H+ G&A + Distribution**	**Total Unit Cost**	**% Savings**	**Savings Compared to YTD FY-14 10¢ through March 2014 1,650 M Coins**	
FY13 10¢		2.27	$0.0204	$ 0.0307	$ 0.0149	$ 0.0456		$ -	a
FY14 10¢ (92-8) -->3/31/14 825M coins	1,650 M		$0.0169	$ 0.0267	$ 0.0140	$ 0.0407	-10.7%	$ 8,027,772	b
80-20 Cu-Ni Clad		2.27	$0.0165	$ 0.0262	$ 0.0140	$ 0.0403	-1.2%	$ 791,839	e
Multi-Ply plated steel (p)		2.00	$0.0217	$ 0.0231	$ 0.0140	$ 0.0371	-8.9%	$ 5,956,892	e
Nickel plated steel (p)		2.00	$0.0225	$ 0.0238	$ 0.0140	$ 0.0379	-7.0%	$ 4,735,956	e
25¢	**Annual Volume**	**Weight (grams)**	**Metal Cost**	**Metal + Supplier Fab + USM Direct Production**	**USM O/H+ G&A + Distribution**	**Total Unit Cost**	**% Savings**	**Savings Compared to YTD FY-14 25¢ through March 2014 1,062 M Coins**	**Notes**
FY13 25¢ 1,062 M Coins		5.67	$0.0465	$ 0.0714	$ 0.0336	$ 0.1050		$ -	a
FY14 25¢ (92-8) -->3/31/14 592.2M coins	1,062 M	5.67	$0.0408	$ 0.0631	$ 0.0281	$ 0.0912	-13.2%	$ 14,715,198	b
80-20 Cu-Ni Clad		5.66	$0.0396	$ 0.0619	$ 0.0281	$ 0.0900	-1.3%	$ 1,252,998	e
Multi-Ply plated steel (p)		5.03	$0.0346	$ 0.0370	$ 0.0281	$ 0.0651	-28.6%	$ 27,718,074	q
Nickel plated steel (p)		5.03	$0.0371	$ 0.0395	$ 0.0281	$ 0.0676	-25.8%	$ 25,020,594	q
Tin plated CPZ (p)		4.54	$0.0379	$ 0.0403	$ 0.0281	$ 0.0684	-25.0%	$ 24,171,079	q

Notes:

a = FY13 Actuals
b = FY2014 10/1/13–3/31/14
e = Estimate
q = Supplier quote

Key:

(cs)=clad strip
(p)=plated
(s)=strip
Green=seamless alternative and Red=cancelled alternative

Assumptions:

> FY13 unit cost data is from FY13 Annual Report
> US Mint Production, G&A, and distribution costs are FY14 YTD through March
> Volumes are annualized FY14 (YTD through March) volumes.
> Savings are calculated based on FY14 YTD through March total unit costs and volumes